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REPORT

ON

THE BUILDING STONES

OF THE

UNITED STATES,

AND

STATISTICS OF THE QUARRY INDUSTRY

FOR 1880.

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* Plate LV: for *Maryland*, read "Missouri".

LETTER OF TRANSMITTAL.

WASHINGTON, D. C., *February* 19, 1883.

Hon. CHARLES W. SEATON, *Superintendent of Census.*

SIR: In accordance with your request, I have examined and revised the following report upon the building stones and quarry industries of the United States.

This work was undertaken jointly by the Census Office and the National Museum, and placed in charge of the late Dr. George W. Hawes, then curator of the department of mineralogy and lithology in the National Museum.

The work as planned by him comprised the collection of very full and complete statistics from all quarries in the United States doing business during the census year to the extent of $1,000, and the making of a collection of quarry specimens for examination for the purpose of this report and for deposit in the National Museum as a reference collection. These plans contemplated also a thorough study of the building stones with reference to their hardness, durability, beauty, chemical composition, microscopic structure, and geological relations. Dr. Hawes lived long enough to see his plans well under way, the collection practically completed, and much of the microscopic and chemical work done. His health failed in the fall of 1881, and he was obliged to give up work, when his principal assistant, Mr. F. W. Sperr, was placed in temporary charge. Dr. Hawes' health continued to fail, and at last, on June 22, 1882, he died, at Colorado Springs, Colorado.

Not long after, Mr. Sperr's health failed, and he was obliged to give up the control of the work, when it was left in charge of Mr. Thomas C. Kelly, by whom it was brought to its present stage.

As assistants in the field-work of this investigation Dr. Hawes enlisted the services of many of the most prominent geologists and mineralogists of the country, and to them is due in great measure whatever success may have been attained in this investigation. They have devoted to it much valuable time and attention, and in every way have shown the utmost interest in prosecuting it thoroughly. Many of these gentlemen have also rendered valuable services in furnishing manuscript notes regarding the quarries of their respective districts, which, from the local knowledge of the author, is of great value. The statistics and the information concerning the quarries were gathered by the following gentlemen in the areas indicated:

In Maine, Rhode Island, and that portion of Massachusetts east of the Connecticut river, Professor N. S. Shaler, of Harvard university, Cambridge, Massachusetts.

In New Hampshire, Vermont, and that portion of Massachusetts west of the Connecticut river, and of New York east of the Hudson and above the latitude of the north line of Connecticut, Professor C. H. Hitchcock, of Dartmouth college, Hanover, New Hampshire.

In Connecticut, and New York east of the Hudson and south of the latitude of the north line of Connecticut, Mr. Harrison R. Lindsley, of New Haven, Connecticut.

In Manhattan Island and cities in the immediate vicinity of New York, Professor Alexis A. Julien, of the School of Mines, Columbia college, New York city.

In the portion of New York west of the Hudson, and New Jersey outside of the immediate neighborhood of New York, Professors George H. Cook, director of the geological survey of New Jersey, and James C. Smock, of New Brunswick, New Jersey.

In Pennsylvania, Mr. Charles Allen, of Harrisburg, Professor J. P. Lesley, state geologist, and Messrs. Ashburner, Lehman, D'Invilliers, and other members of the second geological survey of that state, and Messrs. F. W. Sperr and Thomas C. Kelly.

In Maryland, Delaware, and Virginia, Professor J. H. Huntington, Boston, Massachusetts, Professor Charles E. Munroe, United States Naval Academy, and Mr. H. K. Singleton, of Mississippi.

In Ohio and Indiana, Professor Edward Orton, Columbus, Ohio.

In Kentucky, Professor J. R. Procter, state geologist, Frankfort, Kentucky.

In Michigan, Wisconsin, and Illinois, Professor Allen D. Conover, Madison, Wisconsin.

In Minnesota, Iowa, and Dakota, Professor N. H. Winchell, state geologist of Minnesota, Minneapolis, Minnesota, and Mr. W. J. McGee, Farley, Iowa.

In Missouri and Kansas, Professor G. C. Brodhead, state geologist of Missouri, Pleasant Hill, Missouri.

The statistics in the southern states were collected by Mr. Henry E. Cotton and Dr. A. Gattinger, of Nashville, Tennessee, and those of the west by Mr. William Foster, of Denver, Colorado.

A number of assistants, who also rendered much valuable service, was employed by the gentlemen above mentioned. In addition to the above list of regular assistants upon this work, a great many persons aided in extending the scope of the work, especially by bringing to notice some of the great undeveloped resources of the country.

The unfortunate death of Dr. Hawes necessitated a considerable change in the character of the report. It became necessary to curtail what might be called the scientific portion, that relating more purely to lithology, thus giving greater relative prominence to the economic side of the subject. With this exception the original plans of Dr. Hawes have been carried out as far as possible.

The following is a sketch of the topics under which the report is arranged:

Following the introduction, which consists of the discussion of general matters relating to the subject, are tables showing the number of quarries, the capital invested in them, product in the census year, and its value, and other details regarding labor, means of transportation, etc. These tables are given by states and by general classes of rocks, and form a general exhibit of the extent of the quarry business in the country. The quarries of each state which is of importance in this respect are then taken up in detail, the general facts regarding the individual quarries being given in tabular form, with location, kind of rock, structure, quality, color, geological formation, etc. Descriptive text follows each table, and is intended to fill out and complete the matter in the tables in such a way as to give the details which are desirable to be known regarding the quarries of importance. Then follow a description of the use of stone in most of the principal cities of the country, the extent to which it is employed, the kinds of stone principally used, and other matters of importance connected with this subject. This description is accompanied by a table showing the proportion of stone buildings in each city, the class of stones principally used, and their sources, and the stone employed for foundations, pavements, etc. A short table of exports and imports of stone and a brief discussion of a few notable foreign ornamental stones close the report.

In the following report it will be observed that a comparatively small portion of the work bears the name of Dr. Hawes as author, but the amount of this matter must not be taken as in any way the measure of the share which he had in the work. Not only are the inception and plan of the entire work due to him, but a large proportion of the material from which this manuscript was made was collated and drafted roughly by him, though not put in shape for publication. He plowed, sowed, and cultivated that others might reap.

The chemical work of the report and the classification of the limestones were done by Mr. F. P. Dewey, of the Smithsonian Institution, and his report upon the general methods employed by him is included in the introductory matter.

The microscopic examination of the rocks commenced by Dr. Hawes was completed by Mr. G. P. Merrill, of the Smithsonian Institution, and his report upon this subject also is included in the introductory matter.

The illustrations of polished rock surfaces, representing some of our most beautiful and serviceable rocks, were drawn in water color by Mr. Henry J. Morgan.

The chapter upon methods of quarrying, machines, and tools used in such operations was prepared by Mr. F. W. Sperr.

The great bulk of the text, consisting of descriptions of the quarry regions and individual quarries, and of the use of stone in construction in the principal cities of the country, was in the main compiled by Messrs. Sperr and

Kelly from descriptive notes furnished by the different special agents enumerated above. The degree of fullness of these notes depends, therefore, not so much upon the importance of the quarry industries in the different districts as upon the extent of the descriptive matter furnished by the different special agents; and it is doubtless true that undue prominence has on this account been given to certain regions. For example, the quarries of the state of Ohio have been described in great fullness of detail, while the marbles of Tennessee receive but a passing mention. It does not, however, appear to be advisable to throw away a large part of this information for the mere sake of producing uniformity.

The notes of Professor Shaler regarding his district are so full and elaborate that it has been thought best to present them, with little change, over his own name. The same is the case with those for Illinois, Wisconsin, and Michigan, by Professor Conover; for Iowa, by Mr. W. J. McGee, and a portion of the notes concerning Missouri, by Professor Brodhead, the state geologist.

In the chapter upon stone construction in cities New York city is treated exhaustively by Professor A. A. Julien, who in addition to this furnished a paper on the very important subject of the durability of the building stones in actual use in the country.

It should be borne in mind that the statistical tables deal in general only with quarries which produced during the census year to the value of $1,000 or upward. This excludes not only a large number of small quarries, but also many which have in years past produced very extensively, but which were worked little or not at all during the census year.

Nearly all the quarries of the southern states, with the exception of the marble quarries of Tennessee, fall within one or the other of these classes. For instance, out of a large number of quarries in North Carolina, scarcely one, under the above definition, should be represented in the tables.

In this portion of the country this industry is yet in its infancy. The slight demand for stone in construction, owing to the relative cheapness of other building material, especially wood, and the fact that the region contains but a small urban population, have combined to delay its development, and to-day the south is but beginning to realize its immense resources of this kind.

The reader will doubtless find in the text, and especially in that portion relating to stone construction in cities, many references to quarries which are not represented in the tables. These apparent omissions, in the majority of cases, fall into one or the other of the above classes of intentional omissions, that is, of quarries whose importance is not sufficiently great to give them place in the statistical tables, or where the quarries, although large and important, are worked spasmodically, as occasion requires, and were not worked extensively during the census year. Still, as this is practically the first attempt which has ever been made to obtain the statistics of this industry, it is very possible that some important quarries have escaped notice, although every precaution for obtaining completeness which had suggested itself to those having the matter in charge was taken. Wherever practicable, the local knowledge of the state geologists, and of others more or less directly interested in this industry, was utilized, and it is believed that, under the circumstances, the omissions have been reduced to as small a quantity as possible.

Very respectfully, yours,

HENRY GANNETT,

Geographer and Special Agent Tenth Census.

THE BUILDING STONES OF THE UNITED STATES AND STATISTICS OF THE QUARRY INDUSTRY.

Chapter I.—INTRODUCTION.

By Dr. George W. Hawes.

Materials for building may be divided into two classes, natural and artificial. Of the former class may be mentioned, as the principal members, wood and stone, and of the latter class, brick, artificial stone, and iron. The industry of extracting stone for building purposes has been, for convenience in this report, denominated the quarry industry. This term is not accurately descriptive, since all the materials extracted from quarries or open mines are not here described. Coal, metallic ores, limestone when quarried for lime or for fertilizing, and phosphate of lime when quarried for the latter purpose, may be noted as exceptions.

The importance of this investigation will be recognized when it is known that the subject has received little or no attention heretofore in this country, although immense sums are spent annually upon stone as a material in construction.

The first, and indeed the only attempt, so far as known, to bring into notice our resources in building stone was made at the late centennial exposition at Philadelphia, when a general invitation was sent to quarrymen to forward specimens for exhibition. This was generally responded to, and a beautiful collection was the result; but it was by no means exhaustive or representtive, inasmuch as it was a purely voluntary collection.

Many experiments upon the strength of building stone have been made, notably by the officers of the United states engineer corps, and the results, published only in a fragmentary way, are more or less inaccessible. Strength, however, is but one of the factors which determine the relative value of the stone. The factor, primarily, is its accessibility, as the most valuable stone is of but little use for extensive building operations if far from water or railroad transportation. Next in importance is its durability, as well as its capability of resisting climatic influences; and this is a subject upon which very little has been said or written. It is a subject upon which it is extremely difficult to experiment, and yet in this respect it is most desirable that we should possess information. Such knowledge can be gained only by experience, and in many cases dearly-bought experience, and it is therefore important that all facts relating to the durability of stone under the influences of climate should be collated and brought into juxtaposition with one another.

THE COLLECTION.

The considerations already advanced show the desirability, in connection with a work of this kind, of making a systematic collection of specimens of building stones. The popular names given to building stones vary in different parts of the country, and the same name is in some cases applied to most diverse materials. Such words as granite, trap, blue-stone, flag-stone, etc., do not designate stones in such a manner as to enable one to judge of their appearance or characteristics, and, beyond its necessity for purposes of classification, a collection is of such value to architects and builders as to justify its accumulation at government expense. At the centennial exhibition in Philadelphia in 1876 many of our best stones were placed in direct comparison with those from foreign countries, and visitors were surprised to find that our country possessed materials for which we have been in the habit of looking to other lands. This collection was made the subject of a report by Professor J. F. Newberry, of the School of Mines, Columbia College, New York city, which report forms one of the most prominent contributions to the literature upon the general resources of the country in stone.

This collection, however, did not claim to be either systematic or complete. The Census Office has aimed at system and uniformity in the collection and treatment of specimens, in order to insure fair comparison. The size of the specimens was determined by such considerations, it having been the intention that every quarry of importance in the country should be represented in the collection by a cube with edges four inches long. These specimens are dressed in the following manner:

Polished in front.
Drafted and pointed on the left-hand side.
Drafted with rock-face upon the right-hand side.
Entirely rough behind.
Rubbed or chiseled upon top and bottom.

The aim has been to show the appearances of the stone when subjected to such treatment as it will receive when applied to construction and ornamentation. The polished surfaces render prominent many peculiarities of structure and composition which are not evident upon rough surfaces. The only modification that has been allowed has been in the treatment of the front face, which, when incapable of being polished, has received the highest finish which it can be made to receive.

The specimens are of such size as to admit of easy handling and close examination, and are easily accessible to all interested in their study and comparison. The centennial collection has been united with these, and the whole forms one of the attractive features of the National Museum in Washington.

A number of treatises upon building material have been issued in European countries, and the crudeness of their statements concerning the quarries of America is most striking when one notes the size of this collection and the diversity of its specimens. The statements, however, are not to be wondered at, since the authors have had little accessible American literature. It might, however, be assumed that a country of this extent, possessing so great diversities in physical features, would possess a great variety of building stones.

It may be said in general that at this stage of the development of the stone industry in the country there are few quarries which do not produce material possessing something or other to recommend them and to give them an excuse for existing. This can scarcely be otherwise in a land which possesses such an immensity of undeveloped resources in stones of the finest quality.

The collection, however, brings one thing most prominently forward, and that is that at the very doors of buildings constructed of stones brought from great distances materials equal or superior are often found. The lack of confidence in home resources has very frequently caused stones of demonstrated good quality to be carried far and wide, and frequently to be laid down upon the outcropping ledges of material in every way their equal. Development of local resources follows in the wake of good information concerning them, for the lack of confidence in home products cannot be attributed to prejudice. The first stone house erected in San Francisco, for example, was built of stone brought from China, and at the present day the granites mostly employed there are brought from New England or from Scotland. Yet we have no stones in our collection possessing more qualities to recommend them than California granites.

Some of the results of this general ignorance of the resources that this country affords in the way of building stones is shown by the use of stones brought from the Atlantic sea-board in the public buildings of the Mississippi valley. Some of the prominent public and private buildings in Cincinnati, for instance, are constructed of stone that was carried by water and railway a distance of about 1,500 miles. Within 150 miles of Cincinnati, in the sub-Carboniferous limestone district of Kentucky, there are very extensive deposits of dolomitic limestone that afford a beautiful building stone, which can be quarried at no more expense than that of the granite of Maine. Moreover, this dolomite is easily carved; it requires not more than one-third the labor to give it a surface that is needed by granite. Experience has shown that the endurance of this stone under the influences of weather is very great. A building in Bowling Green, Kentucky, which has been standing over forty years, retains the chisel marks with all the clearness they had the day they were made. Yet, because of the want of some authority of an absolute sort, the fear to use this stone has so far kept it from finding a market and has led to the transportation of stone half-way across the continent.

In all other mining industries the product shows the fitness for its use almost at the moment of its production, so that, if the government secures the exercise of proper precaution in the carrying on of the work, the character of the products may be left to be determined by the laws of trade. But in building stones there is always the question of endurance under the action of the weather, which cannot be determined in any easy way. The external aspect of the stone may fail to give any clue to it; nor can all the tests we yet know determine to a certainty in the laboratory just how a given rock will withstand the tests of absorption of our own variable climate and the gases of our cities. The cities of northern Europe are full of failures in the stones of important structures. The most costly building erected in modern times, perhaps the most costly edifice reared since the great pyramid, the parliament-house in London, was built of a stone taken on the recommendation of a committee representing the best scientific and technical skill of Great Britain. The stone selected was submitted to various tests, but the corroding influence of a London atmosphere was overlooked. The great structure was built, and now it seems questionable whether it can be made to endure as long as a timber building would stand, so great is the

effect of the gases of the atmosphere upon the rock. This is only one of the numerous instances that might be cited in which a neglect to consider the climatic conditions of a particular locality in selecting a building material has proved disastrous. Stones having a high ratio of absorption, or which absorb water readily, are not likely to be durable in a climate subject to alternations of dampness and hard freezing; and, as before mentioned, the acid atmosphere of manufacturing cities is injurious to stones made up largely of carbonate of lime. Professor Hull, in his work on the building and ornamental stones of Great Britain and foreign countries, gives the following as the most instructive examples of "buildings in Great Britain of limestones and dolomites which have shown disintegration from the influence of rain charged with acid: Saint Mary's, Redcliffe, in Bristol; the new houses of parliament, and the chapel of Henry VIII in Westminster Abbey. The first is built of oolitic limestone, the second of dolomite, the third of Caen stone, the white limestone of Normandy, of Jurassic age". Professor Hull states further that the presence in humid or wet climates of smoke, or sulphurous, hydrochloric, and other acids, powerfully aids the destructive effects of rain or moisture, as the rain itself takes a considerable amount of the acid from the air and spreads it over the exposed surfaces of the buildings; and that, therefore, for such climates limestone of especially soft, granular, and porous kinds should as far as possible be avoided; also, sandstones which contain a notable percentage of calcareous matter in the form of cement should not be used.

Some of the "black granite" or diabase rocks of New England decay rapidly when exposed to the weather, yet they are, in appearance, of enduring quality.

In a communication to the Census Bureau, Professor N. S. Shaler, of Cambridge, Massachusetts, says:

A few years ago I found the stone from one of these diabase quarries being used for the foundations of the most costly buildings ever erected by Harvard college. A century of exposure would be sure to convert a large part of the faces of these foundation stones into dry sand. It was by a mere chance that I was able to make an effective protest against its use in this building. I know that it has been used in scores of other buildings in the same region.

There are many other stones in use in this country that are open to the same objections; they are fair looking, but have not the necessary endurance, under certain atmospheric conditions, which makes them fatal elements of weakness in any architectural work of importance.

It is not possible for the architect or the builder to make tests and accumulate information concerning the particular qualities of this or that stone; nor is it possible for any association such as the national societies of architects to do justice to the problem. The result is that it is very hard to bring a new quarry stone into use unless it is essentially like some of those already extensively employed. No one builder is willing to assume the risk that may come from the experiment, especially when he is not likely to have the profit that may arise from the use of the cheaper stone. There can be no question that in this way we are debarred from the use of many of the best and cheapest building stones that the country affords. Professor Shaler advises substantially the following plan:

In proposing to myself a method whereby a source of necessary information concerning the building stones of the country may be established, I have taken care to make the element of interference on the part of the state as small as possible. It seems to me that the following plan may serve to accomplish the end in view without undue expenditure or overregulation. There should in the first place be a national collection of building stones whereat the architect may be able to see a sufficient representation of all the building stones the country affords.

The admirable system followed by the Tenth Census has already accumulated at Washington an excellent foundation for such a collection. By the simple plan of having large specimens of the stones heretofore used in all public buildings added to this collection, and further by letting it be known that architects would confer a favor by submitting specimens of the stone used by them, a very valuable collection could be accumulated. In addition to this interior cabinet there should be an open-air collection designed to show the effects of weathering upon the various classes of building materials. This collection would necessarily occupy a good deal of ground, for in many cases several courses of stone, one on top of the other, would be necessary to show the full effect of weathering. The attitude of the wall with reference to the sun, frost, etc., is a matter of importance. It should also include water-cement, roofing materials, and various forms of terra-cotta, from common brick to decorative work. In fact such a collection should be essentially an experimental station on construction materials.

With the view of accomplishing more perfectly the large purposes that could only be accomplished by such a museum, I would suggest that the whole matter of strength of materials used in public edifices should be placed in the control of its superintendent; and that, on the payment of a small fee, the laboratory connected with the museum might examine into the composition and character of building material submitted to it. Each subsequent decennial census will give a chance to revise and extend the researches of this museum.

In addition to the ordinary specimens of building stones, quarry-owners were invited to represent their material in the National Museum by a larger specimen, dressed by themselves and forwarded at their own expense. To this invitation many quarrymen have responded by sending dressed foot cubes or slabs, pedestals, etc., many of which are very beautiful. We have not allowed the prominence thus given to individual quarries to modify or prejudice our opinion of the material. No injustice has thus been done, as no effort was made to gather these blocks, and any one had, and still has, the opportunity, if he wishes, to supplement his exhibition with such blocks. Our 4-inch cubes are, however, to us the most satisfactory specimens, as showing the nature of the material and forming a systematic collection which it would be impracticable to attempt to make of larger blocks.

One of the large halls in the National Museum at Washington has been set apart for the exhibition of this census collection of building and ornamental stones, and no trouble has been spared by the authorities in the attempt to show each specimen to the best advantage. They are placed in glass cases, in front of a suitable background; each rests on a block, and a card designating the stone and the features of particular interest in connection with it is tacked upon this block, where it can be easily read.

The centennial collection before mentioned, or so much of it as was presented to the Smithsonian Institution, is placed in the hall. The addition which it has made to the census collection is mostly composed of foreign stones.

The supervising architect of the treasury, Mr. Hill, has also kindly given a large portion of the collection which has accumulated in his office, to be used in the study and in supplementing the collection.

THE MINERALS IN BUILDING STONES.

A stone is of little consequence for purposes of construction unless it exists in large quantities, and therefore the principal constituents are the commonest of minerals and few in number. Microscopic examination increases the number of the species quite considerably, and at times those present in smallest amount are of great importance in the determination of economic properties. As these minerals are sufficiently described in any mineralogical treatise, it is only necessary to mention the names of those which occur in building stones.

The mineral compositions of stones are much simplified by the wide range of conditions under which the commonest minerals can be found, thus allowing their presence in all classes of rocks. Thus quartz, feldspar, mica, hornblende, and pyroxene can be found in a mass cooling from a state of fusion; they can be crystallized from solution, or be formed from volatilized products. They are, therefore, excluded from no classes of rocks, since there is no process of rock formation which determines their absence.

Most of the commonest minerals, like feldspar, mica, hornblende, pyroxene, and the alkaline carbonates, possess also the capacity of adapting themselves to a wide range of compositions. Feldspar, for example, can take more or less silica, lime, soda, or potash into its composition. Hornblende and pyroxene may be pure silicates of lime and magnesia, or iron and manganese may take the place of a portion of these bases. Lime carbonate may be very pure, or magnesia may take the place of any proportion of the lime.

These considerations indicate the reason of the extreme simplicity of rocks as regards their chief constituents, and that whatever may be the composition of a mass within the limits which nature allows, and whatever may be the conditions of its origin, the probabilities are that it will be essentially formed of one or more of a half dozen minerals in some of their varieties.

But however great may be the adaptability of these few minerals, they still are subject to very definite laws of chemical equivalence; there are elements which they cannot take into their composition, and there are circumstances which retard their formation while other minerals are crystallizing. Therefore, in a mass of more or less accidental composition, other minerals may always be expected to form in considerable numbers and minute quantity.

For convenience we may therefore divide the minerals into two groups: the first to contain those minerals with their varieties which compose the mass of rocks, and any one of which may be the chief ingredient of a rock; and the second to contain those which never compose the mass of a building stone, and are, when present at all, usually present in small amount.

The following is a list of the mineral constituents of most building stones:

1. Quartz.
2. Feldspar.
   - 2*a*. Orthoclase.
   - 2*b*. Microcline.
   - 2*c*. Albite.
   - 2*d*. Anorthite.
   - 2*e*. Labradorite.
   - 2*f*. Andesite.
   - 2*g*. Oligoclase.
   - 2*h*. Triclinic feldspar (undetermined species).
3. Mica.
   - 3*a*. Muscovite.
   - 3*b*. Biotite.
   - 3*c*. Phlogopite.
   - 3*d*. Lepidolite.
4. Amphibole or hornblende.
   - 4*a*. Tremolite.
   - 4*b*. Actinolite.
   - 4*c*. Common hornblende.
5. Pyroxene.
   - 5*a*. Malacolite.
   - 5*b*. Sahlite.
   - 5*c*. Diallage.
   - 5*d*. Augite.
6. Calcite.
7. Dolomite.
8. Serpentine.
9. Talc.

ELEMENTS.

10. Iron.
11. Copper.
12. Carbon.
13. Graphite.

SULPHIDES.

14. Galenite. (Lead glance.)
15. Sphalerite. (Zinc-blende.)
16. Pyrrhotite. (Magnetic pyrites.)
17. Pyrite. (Pyrites.)
18. Chalcopyrite. (Copper pyrites.)
19. Marcasite. (White pyrites.)
20. Arsenopyrite. (Mispickel, or arsenical pyrites.)

CHLORIDE.

21. Halite. (Common salt.)

FLUORIDE.

22. Fluorite. (Fluor-spar.)

OXIDES.

23. Tridymite.
24. Opal.
25. Corundum. (Emery.)
26. Hematite. (Specular iron.)
27. Menaccanite. (Titanic iron.)
28. Magnetite. (Magnetic iron.)
29. Chromite. (Chromic iron.)

OXIDES—continued.

30. Limonite. (Hydrous iron oxide, rust.)
31. Spinel.
32. Rutile.
33. Pyrolusite. (Manganese binoxide.)

ANHYDROUS SILICATES.

34. Enstatite.
35. Hypersthene.
36. Acmite.
37. Glaucophane.
38. Beryl.
39. Chrysolite. (Olivine.)
40. Danalite.
41. Garnet.
42. Zircon.
43. Epidote.
44. Allanite.
45. Zoisite.
46. Iolite. (Cordierite.)
47. Scapolite.
48. Elaeolite.
49. Sodalite.
50. Cancrinite.
51. Chondrodite.
52. Tourmaline.
53. Andalusite.
54. Fibrolite.
55. Cyanite.
56. Topaz.
57. Datolite.
58. Titanite. (Sphene.)
59. Staurolite.

HYDROUS SILICATES.

60. Petalite.
61. Laumontite.
62. Prehnite.
63. Thomsonite.
64. Natrolite.
65. Analcite.
66. Chabazite.
67. Stilbite.
68. Heulandite.
69. Harmotome.
70. Kaolin.
71. Chlorite.
71*a*. Jeffersonite.
72. Rapidolite.
73. Penninite.
74. Prochlorite.

PHOSPHATE.

75. Apatite.

SULPHATE.

76. Gypsum.

CARBONATES.

77. Ankerite.
78. Siderite.
79. Rhodochrosite.
80. Aragonite.
81. Malachite.
82. Azurite.

METHODS OF STUDY.

The methods usually applied to the study of building materials are eminently practical. The required qualities of good stones are well understood, and direct processes are employed in order to ascertain the strength, hardness, and durability. Experience most of all has aided in the development of knowledge, and this sometimes has been gained at great expense. Though the results of actual practice are the final criterions, they are too slowly gained, and hence scientific and practical study can be combined to the advantage of those using stone.

On the other hand, the application of scientific methods to economic problems, while bringing the later results of study into the domain of daily life, has never been carefully performed without incidentally developing some things of interest and value to science. There are no absolute rules to lay down by which stones are to be judged, however simply such are recorded in the text-books.

Stones which have lain in the quarry for years, and which show the effects which time can produce, are usually inferior specimens that have been rejected, and quarries which have produced bad materials may also subsequently produce the best, and *vice versa*.

The methods which have been employed in the study of compositions and structures are, however, such as require some explanation.

The purposes of the work demand a determination of the compositions and structures of the various rocks, as these in combination with the location and geological features determine the applicability of the stones and explain their peculiar properties. The microscopic examination of thin sections leads most directly to the desired results. This method of study in the hands of the microscopic lithologist has been most fruitful in developing valuable and interesting knowledge of a scientific character. By its means the nature and the composition of almost all of the commonly-occurring rocks have been determined, and geological progress in later years has been modified and directed to a certain extent by the results of microscopic study. Exactly those same features which are of importance in scientific study are the ones which determine the value and appearance of building stones; and there is no distinction between the scientific and the practical.

The method will here be described with the least detail that will render the accompanying plates comprehensible to those who are interested in the results but unacquainted with the method. Any who wish to apply the method will seek fuller information in the treatises devoted to the subject.

A thin fragment of stone with a circumference equal to that of a silver quarter-dollar is knocked from the larger block with a hammer or a pitching-tool; or when difficulties are encountered in obtaining thus a favorable

piece, the same is sawed off from the block with a diamond saw. When a flat, smooth surface has been ground upon one side of this chip, and which reaches the outer circumference of it at every point, the chip is glued firmly upon a slide of glass, by means of hot Canada balsam, in such a way that the new, smooth surface is very nearly in contact with the glass. The Canada balsam hardens on cooling, and the stone will adhere to the glass with great tenacity. The glass slide thus furnishes a support, by means of which the stone can be held in contact with a revolving disk supplied with wet emery, and ground away on the other side until it becomes thin and transparent. By means of graded emery the stone is reduced to a very thin film; a good section being less than one-thousandth of an inch in thickness; and under this treatment even the most opaque stones which are employed for building purposes become transparent. It will be seen that in a section thus prepared the film which remains is composed of sections through the components of the rock, and that its grains or crystals have been undisturbed. An examination of the section by means of the microscope will show not merely the various substances which compose it, but also the method according to which they are arranged and by which they are attached to one another. With a magnifying power the minutest inclusions can be recognized, and by the application of optical methods the ingredients can all be determined. It is found that the stones which we ordinarily employ are much more complex in composition than once was thought, and the minerals which compose the stones are frequently different from what would be supposed by examination with the unaided eye. For the improvement and preservation of the section it is usually transferred to a new, clean slide, and covered with a thin film of glass, which is firmly fixed by gluing with Canada balsam.

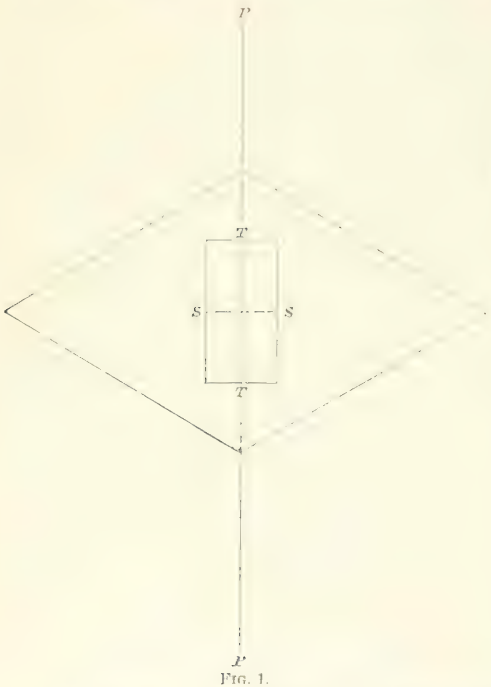


FIG. 1.

The examination of thin sections has been found most useful to botanists, zoologists, and pathologists, who have long employed the method for most important examinations. The method was recommended to the mineralogists by Cordier in 1816, but neither chemical nor optical methods were then enough advanced to render its use practicable. Thin sections were made by Mr. H. Witham in 1831, when studying the microscopic structures of fossil plants, which necessitated making thin sections of materials practically according to the method described. Mr. H. C. Sorby first applied the microscope to lithology, and discovered many facts. Since that time a score of lithologists have occupied their time in cutting sections of all possible stones, and have developed a knowledge of their compositions, structures, and features, but as a rule with strictly scientific ends in view.

THE OPTICAL EXAMINATIONS.—If sections prepared as described are placed upon the stage of the microscope, simple observation will indicate that most stones are complex; that their ingredient minerals are more or less impure; that they possess peculiarities of cleavage, fracture, and color; that in some cases they are more or less decomposed; that they are united with one another in very different ways in different cases, and that a variety of minerals is frequently present in small amount not visible to the unaided eye.

It will also be noticed that all the sections of the same minerals do not look alike, and that there is a probable difference between many which do look alike. This is especially the case in the white minerals which are present in considerable numbers in building stones, and other minerals with weak colors become white when ground so thin. In order to identify the minerals present it is necessary to use certain optical appliances which develop more individual peculiarities. When the polished surface of a stone is examined, its appearance is determined by the character of the light which it reflects. The amount of light reflected from the outer surface determines its brilliancy, the light reflected from internal surfaces imparts iridescence and reveals structure, and the light absorbed determines the color of the stone. But when a section of a stone is examined the appearance of this section depends upon the character of the light which it transmits. The colors which are reflected from a surface may be quite different from those which are transmitted by the body, and the general appearance of a section, therefore, is entirely different from that of a surface.

When light enters from a medium of one density into a medium of another density, as, for example, when it enters from the air into water, if its direction is oblique to the surface separating the two substances it is deflected toward a perpendicular to the surface. This is called refraction, and the relative amount of the deflection which

is caused when light enters different substances from the same medium is expressed by the index of refraction. Minerals possess great differences in their indices of refraction, these differences being manifested in thin sections. A mineral which possesses a high index of refraction, and which consequently deflects a beam of light to a greater degree, is apparently thicker than a mineral with a small index of refraction, since the refraction causes a retardation of the light, which is equivalent in effect to the thickening of a mineral with a less refractive index. Moreover, the surface of a section being covered with Canada balsam, the appearance of this surface is modified by the refractive properties possessed by a section. If a mineral possesses a high index of refraction there is a greater difference between its index and the index of the balsam than in the case of a mineral with a low index of refraction, and consequently its surface will appear rough, since all the asperities which this surface possesses will become evident on account of the alteration in direction and the change of velocity which will take place when the light emerges from the surface of the section. The minerals of crystalline rocks possess generally quite high indices of refraction, and the beauty of polished surfaces is much enhanced thereby. The effects of refraction are much modified by the crystalline structure of the minerals, and are dependent upon this structure.

A crystal, in the modern acceptation of the term, is a homogeneous substance, the ultimate particles of which are definitely arranged. The physical properties, such as cleavage and hardness, which are of importance in building stones, are determined by this molecular arrangement. If a crystal develops in a space surrounded by fluid or by plastic substances, it will develop into a form bounded by planes which, in position and direction, are characteristic of the substance. In rocks, as a general rule, there has been no opportunity for such crystalline development, and the substances by their mutual contact have so interfered with one another in their development as to give them forms which are arbitrary and, to a certain extent, accidental. The internal arrangement of the substances in crystalline form is, however, as perfect as if the external forms were characteristically developed. Rocks may therefore be said to be made up of crystals which, in some cases, as in porphyries, possess characteristic form, but which usually are granular and irregular in form, and are either united upon their edges or cemented together by some interposed foreign substance.

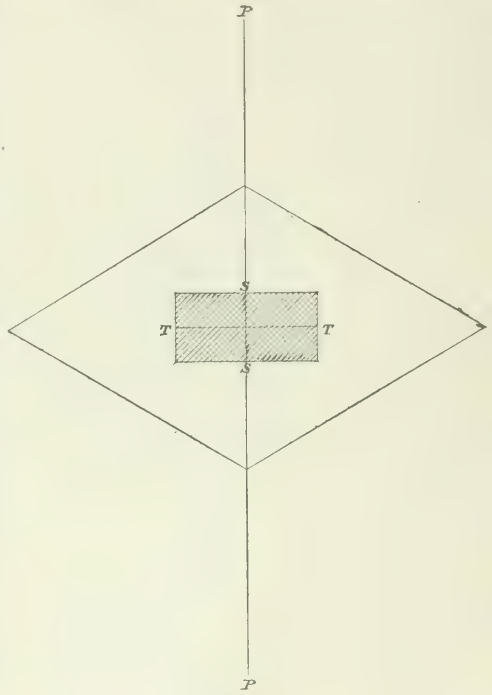


FIG. 2.

One of the fundamental properties of crystals is that the light which passes through them passes in definite directions and is submitted to definite modifications. An ordinary beam of light is composed of vibrations which differ from the vibrations of sound in that while sound is propagated by vibrations the axes of which are parallel with the direction of propagation, light is composed of vibrations which take place in all directions perpendicular to the direction of the beam. The color of a beam of light depends upon the duration of the vibration, and the intensity depends upon the amplitude. If a beam of light enters from the air into a non crystalline structure it suffers no further modification than the simple refraction; if it enters a crystal it may pass through it as through a non-crystalline substance, or it will be modified in such a way as that the vibrations which have been stated to take place in every direction about the axis of transmission will all be reduced to two planes which are at right angles to each other and are definite in direction. As to the method in which the light is modified in passing through the crystal, that depends upon the nature of the substance and the degree of symmetry which the crystal possesses. The simplest illustration of such a modification is seen by examining a dot through a piece of the ordinary calcite or Iceland spar; the dot will appear double, and the two apparent dots will have different appearances, dependent upon the difference of refraction of the two parts of the ray, which are separated in the crystal and are vibrating at right angles to each other. If a ray of light has passed through a crystal, and has had its vibrations thus all reduced to two planes, one of the two portions of light is what is called polarized; and the effects of this kind of light can be much better observed if by means of some contrivance one of the sets of vibrations can be absorbed so that a light can be obtained, all the vibrations of which take place in a single plane. Polarized light, then, as distinguished from ordinary light, is light the vibrations of which occur in one plane instead of taking place in an indefinite number of planes, as in ordinary light. Such polarization can be effected

in a variety of ways. By passing through a plate of tourmaline cut parallel to the axis of the crystal the light, as previously explained, is divided into two sets of vibrations at right angles to each other, one of the sets being almost entirely absorbed, while the other is mostly transmitted as a polarized beam. Polarization is ordinarily effected by passing a beam of light into a crystal of calcite, which is cut in such a manner that one set of vibrations is allowed to pass through while another set is reflected away. A crystal so modified as to accomplish this object is called a Nicol prism, as such prisms were first made by the celebrated scientist Nicol.

Let us suppose that a beam of light is allowed to pass through a Nicol prism, and that its vibrations are all reduced to one plane, which vibrations take place parallel to the shorter diagonal of the Nicol prism, as represented in the accompanying Fig. 1; P P will then represent the plane of vibration of the light. If the aforementioned plate cut from a tourmaline crystal be now placed above this Nicol prism so that the long axis of the crystal plate shall coincide with the line P P, the crystal when looked through will be illuminated by light, the vibrations of which take place parallel to its axis, and it will appear of a color brown or blue, according to the variety of tourmaline thus examined. If upon this same Nicol prism the plate of tourmaline be laid with its long axis perpendicular to the line P P, as shown in Fig. 2, the light passing through the Nicol prism will have its vibrations confined to a plane perpendicular to the axis of the tourmaline, and in this direction, as has been before mentioned, the tourmaline allows but little light to pass. A tourmaline crystal, therefore, placed above a Nicol prism, will appear light when placed with its axis parallel to the short diagonal of the Nicol prism, and dark when placed with this axis parallel to the long diagonal; and in general the appearance of crystals may depend more or less upon the relation of their axes to the planes of vibration of the light which passes through. This difference is expressed by the word dichroism. A great many minerals are dichroic, as is abundantly illustrated in the figures.

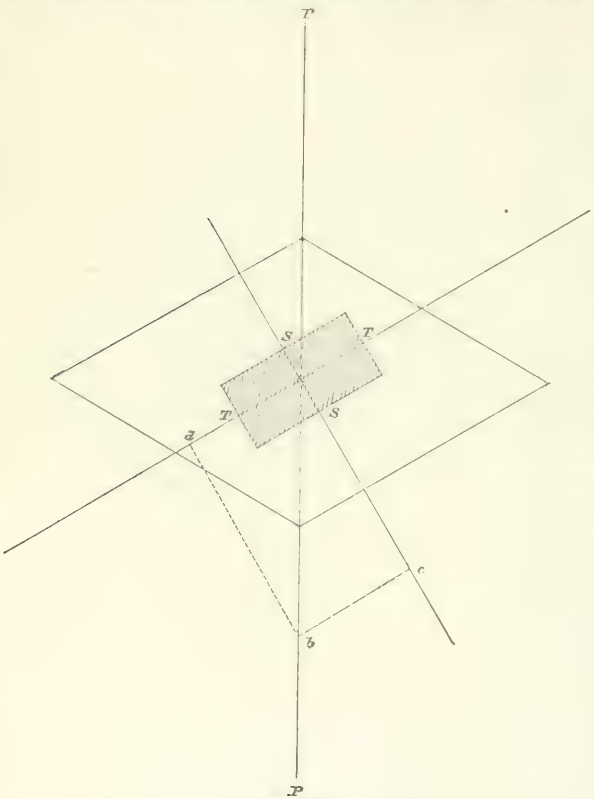


FIG. 3.

If the Nicol prism shall remain in the same position as before, and the tourmaline crystal shall be placed in a diagonal position, then the light which, after passing through the Nicol prism, vibrates in the plane P P meets the tourmaline crystal in a plane which coincides neither with its longer axis or the perpendicular thereto, as shown in Fig. 3; it therefore cannot pass through the crystal in the plane P P, since, as before explained, the only planes in which the light can pass through this crystal are a plane parallel or a plane perpendicular to the axis of the crystal. Meeting now the crystal in an oblique direction, the ray can only pass through it by resolving itself into two parts, according to the parallelogram of forces.

Let *a b* represent the intensity of the vibration as it emerges from the Nicol prism; this ray will divide itself into the part *b c*, which will pass through the crystal in the plane T T and into the part *b d*, which is perpendicular to the line T T, and which, as far as possible, will pass through the crystal in this direction. The crystal in this position will be illuminated by the light which passes parallel to the two directions at right angles to each other in the crystal, and will appear as if examined by ordinary light.

The above explanation of dichroism will explain a great many of the differences in the appearances of minerals when seen in their sections under the microscope; and it also explains a number of appearances which are commonly observed without the aid of instruments. For example, when one looks through a crystal of mica in a direction perpendicular to the laminæ, the color is determined by the light which vibrates in directions parallel with the laminæ, and is of a certain color. If one looks at a crystal of mica in a direction parallel with the laminæ the crystal is illuminated partly by light which vibrates perpendicular to the laminæ, and the color is consequently different. The dichroism of minerals, thus determining a great many of their appearances, is of both economic and scientific importance.

If the light which has passed through the Nicol prism in the plane P P, as before explained, shall be compelled to pass through another Nicol prism exactly like the first one, but placed in a direction with its short axis perpendicular to the plane P′ P′, the light will meet this Nicol prism in such a way that the light cannot pass it; for this Nicol prism, being like the first, reflects away all of the vibrations which enter it parallel to its longer diagonal. Through two Nicol prisms placed in this position light cannot therefore pass, and the portion of the field covered by both of them will appear dark: and if the tourmaline plate be interposed between them with its long axis parallel to the short diagonal of the lower Nicol prism, the light after passing through the lower Nicol prism will pass through the tourmaline as before explained, and will be cut off as before by the upper Nicol prism. The interposition of the tourmaline will therefore produce no effect, and it will appear black when thus placed between two Nicol prisms, as indicated in Fig. 4.

But let it be supposed that two Nicol prisms be placed together, with their shorter diagonals in the directions P P and P′ P′; that the crystal of tourmaline be placed between them in such a way that its axis does not correspond with the diagonal of either Nicol prism, as shown in Fig. 5, the light will, as before shown, be resolved into two parts in order to pass through the tourmaline in the planes *a c* and *a d*. If we follow the course of the ray *a c*, we find that it meets the second Nicol prism in a plane which does not correspond to either its shorter or its longer diagonal; as the light must pass into the prism parallel to one or both of these diagonals, the ray *a c* is again divided according to the parallelogram of force and enters the Nicol prism in two planes with an intensity and a direction represented by *a e* and *a g*. The light vibrating in the plane *a g* is in the upper Nicol prism reflected away, and only the light represented by *a e* passes through it. If we follow the course of the ray represented by *a d* in like manner, it is seen that it must be divided into two parts, vibrating in planes respectively parallel to the shorter and the longer diagonal of the Nicol prism, and in like manner represented in direction and intensity by the lines *a k* and *a m*; *a k* in the upper Nicol prism is lost by total reflection, and *a m* passes through. We now see that by the interposition of the crystal with its long axis placed diagonally a decomposition has been brought about by means of which two rays, represented by *a e* and *a m*, are caused to vibrate in the same plane after having passed through different experiences. The possibility of interference becomes immediately evident, for if a greater retardation has been effected by passing through the crystal in a direction parallel to the prism than in passing perpendicular to the prism, then the two parts can no longer vibrate in unison, and when they are brought back into the same plane with each other they will be sure to interfere. This interference, in fact, takes place under such circumstances, and the result is the production of most brilliant colors, the tints of which are dependent upon the nature of the substance, the thickness of the plate of the crystal interposed, and the position of the plate or section with reference to the diagonals of the Nicol prisms.

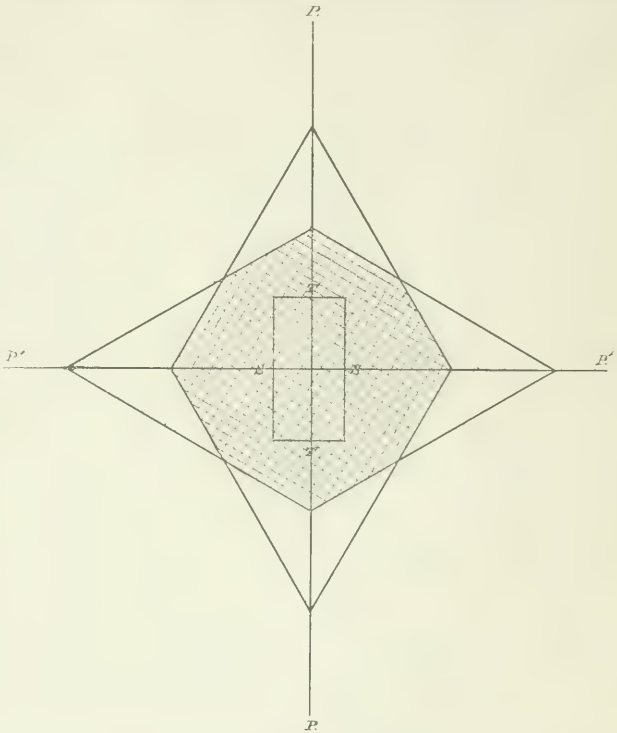


FIG. 4.

As the position with reference to the Nicol prisms brings about such modification, it is evident that the employment of polarized light will develop many peculiarities of structure and arrangement which could not otherwise be detected. In polarized light, minerals which may give no indication of their nature in ordinary light may exhibit such distinctive properties as render their determination very easy.

Those crystals through which light passes in two planes at right angles to each other, as distinguished from those substances through which the light passes without any further modification than a simple change of direction, are called double refracting crystals. These crystals show such peculiarities in their double refraction that it is possible to classify them into systems identical with those which would result from a study of their outer forms were they possessed of perfect external development.

The mode of crystallization determines, therefore, the way in which light is modified by its passage through a section, and individual substances possess in addition their own peculiarities which enable them to be determined. The optical characteristics depend upon the degree of symmetry which crystals possess, and the following are some of the properties which substances of like crystalline character will exhibit: Amorphous substances, such as glass, which occurs in the volcanic rocks, and which are without any crystalline structure, will possess the property of single refraction, will not modify the light by changing the planes of its vibration, and consequently the effects of dichroism and of color with Nicol prisms will not appear, except as they may be caused by a strain or unequal pressure which may give to such a substance a temporary structure.

A crystal belonging to the isometric or regular system is symmetrically developed about the central point. In such bodies the molecular arrangement is therefore such that sections cut in any direction are alike as regards two lines which may be drawn in the section at right angles to one another; there is consequently no double refraction, and such minerals are optically like amorphous substances, save that they may possess definite cleavage, crystalline outlines, inclusions arranged in a definite manner, or some other peculiarities which may demonstrate that they belong to the group of regular crystals. Garnet, fluor-spar, and some other substances that are found in the rocks belong to this class.

Crystals built in the form of a square or of a hexagonal prism, like tourmaline and calcite, possess, however, a different degree of symmetry. In a section of such a prism parallel to the base, any two lines drawn through the center perpendicular to each other would intersect the crystal section in the same manner, and the two lines would be therefore crystallographically identical; there would be no cause for double refraction, and the section would therefore appear between Nicol prisms like the preceding.

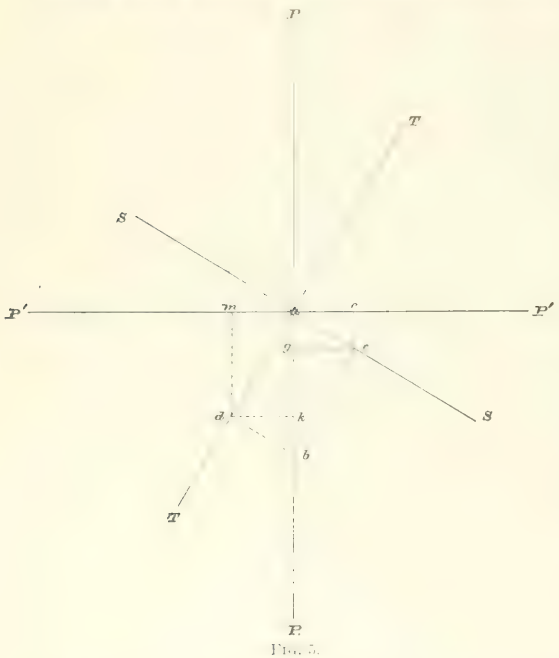


FIG. 5.

If, however, a section be cut from such a prism parallel to the long axis, two lines drawn in this section perpendicular to each other will divide the section in very different manners, and these lines will bear different relations to the crystal section. A line parallel to the longer direction of the section or a line perpendicular thereto will each divide the crystal into two symmetrical halves, which, however, in the two cases are quite different. Such a section will be double refracting, and when placed between the two Nicol prisms will modify the direction of the vibrations which will take place in two planes, one parallel and one perpendicular to the crystal, and one of these sets of vibrations will be retarded more and refracted more than the other by passing through the crystal. Such a section will therefore be colored in whatever position it may occupy between the Nicol prisms, save when its long or its short axis is parallel with one of the diagonals, as shown in Figs. 4 and 5.

If a crystal be developed in such a way that length, breadth, and height are all different, but so that the sides of the prism are perpendicular to the base, as in the case of mica, then sections cut in any direction parallel to the sides of this prism will possess the properties which have been above described as belonging to a section cut parallel to the long direction of a square prism, for such sections will possess the same degree of symmetry and therefore the same optical propertie

If a crystal is developed in such a way that one of the faces of the prism is perpendicular to the base and the others are not, as in the case of common feldspar, then sections parallel to the base and to one side would be parallelograms resembling the long section from a square prism, and would have like optical properties. Other sections cut parallel to the oblique faces of the prism would be rhomboidal in form, and would not possess such lines of symmetry. Lines parallel to the edges of the prism would not divide the section into two parts which would be alike on the two sides of the lines, and these lines would therefore no longer determine the planes in which the light will pass through the section. No two lines perpendicular to each other in such a section can be crystallographic lines, and as the light must pass through such a section, like all others, in two planes which are at right angles, these directions must be independent of the crystal edges, and will depend on the individual mineral rather than on a general system of crystallization. One single example will illustrate all these principles.

Let Fig. 6 represent a crystal of feldspar which belongs to the monoclinic system, last described, and which, if thus simply crystallized, would have the planes on the two sides of the lines *a c* and *a d* at right angles to each other, while the planes on the sides of *a b* would form an obtuse angle. Sections cut parallel to the base and the front face of this prism would then be right-angled parallelograms, and lines through the centers of these faces and parallel to the sides would be at right angles to each other, and would divide them into equal and symmetrical halves. These represent, therefore, the planes in which the light must vibrate in passing through the crystal, and are the planes which must coincide with the diagonals of the Nicol prisms, or interference and colors will be produced.

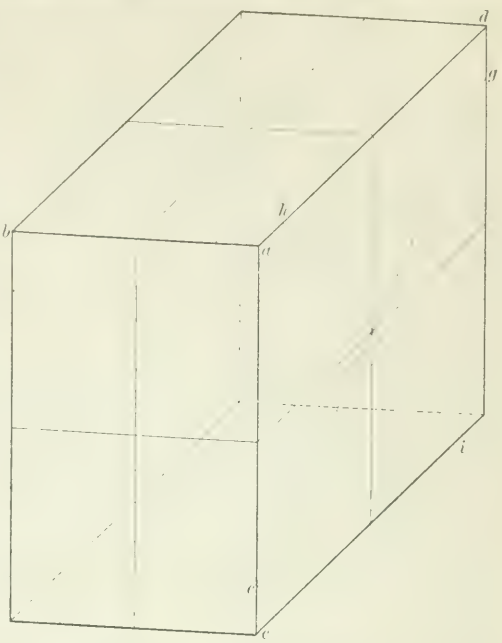


FIG. 6.

The plane on the side, however, is not a parallelogram, and lines parallel to its sides are not perpendicular to each other. The light, therefore, finds two directions, for example, *e g* and *h i*, which are at right angles to each other, in which its vibrations take place. These directions, which make a certain angle with the lines parallel to the edges *a c* and *a d*, have the same position in all crystals of like substances, and occupy different positions in crystals that belong to this system, but are of different substances. These lines are the lines which correspond with the lines parallel to the edges of the crystal in the sections parallel to the other faces, and the angle made by the optical and the crystallographic lines can be measured, and its determination may identify the species of the substance.

Only one case remains to consider. If a prism is so developed that it possesses no right angles, then sections parallel to any face are like the face on the side of the prism in our example, and therefore all its sections will have the properties attributed to sections parallel to that face, and no sections will be found in which the planes of vibration of the light are parallel to the edges of the prism.

A great many more optical effects can be produced by causing other modifications in the light; for example, by making it convergent by means of lenses before it passes into the section. Effects thus obtained elucidate those that have been described, which are seen in simple parallel light. In this work only the optical features that have been described are referred to.

When these principles are applied to the microscopic examination of thin sections we are able to identify all of the constituents which the rock contains by means of the differences which the minerals exhibit either in ordinary or in polarized light. The determination is simplified by the circumstance that the number of minerals which take part in the composition of common building stones is not large.

When a section is placed upon the stage of the microscope most of the ingredient minerals are transparent, and the number which do not become transparent under this treatment is so small that there is no great difficulty in discriminating between them. To determine the opaque ingredients the light is cut off from beneath the stage of the microscope, when the color of these opaque minerals, as they appear by a reflected light, is seen: magnetite is bluish-black, pyrites yellow, etc.

Those minerals which are more or less transparent in the section exhibit the colors which they possess by transmitted light; but, in accordance with the principles already explained, sections of the same substance may be differently colored according to the directions in which their crystals are intersected. A considerable number of the minerals may be identified by their colors and appearances, and others may be identified by known peculiarities of fracture, cleavage, and decomposition.

If a Nicol prism is inserted beneath the stage of the microscope it will not essentially modify the appearance of most of the minerals, but as it will reduce the vibrations of the light which illumines the section to a plane, the phenomena of dichroism will become apparent, and by means of these phenomena some of the ingredients will be identified.

If a second Nicol prism is placed above the first, so that the section lies between the two, then all the phenomena of polarized light become evident; and if these Nicol prisms are placed in such a position that their shorter diagonals are crossed at right angles, and that the direction of these shorter diagonals is accurately known, then the relationship between the diagonals of the Nicol prisms and the planes in which the light vibrates when passing through the crystal section can be determined, and little doubt concerning the composition of any mineral in ordinary rocks will remain after the application of all these methods.

CLASSIFICATION.

The nomenclature in general use for materials of construction is very simple. It consists of a few popular names with no defined significations. These names are derived at times from certain characteristic appearances, and sometimes from the uses to which stone is applied. They answer most of the purposes of constructors; but, when examined more critically, stones which pass under the same name are frequently found to be so different as to necessitate their wide separation from one another in classification.

Some so called granites in the United States do not contain one of the minerals which compose certain other well known granites, and possess nothing in common with them except their granular structure. Such differences in composition essentially modify the economic properties of the stone, and there is for this reason a positive advantage in a more extended nomenclature. Closer discrimination in this direction will also necessitate a more critical consideration of the stones from different sections of the country. We hear very frequently of such things as Ohio sandstone, Maine granite, etc., which are terms that include stones that are incapable of being grouped; and the cases are not rare in which, by reason of such generalizations, the good or bad reputation of certain stones has unjustly passed over to its neighbors.

Individualities of structure and composition of the greatest scientific interest are usually identical with the features most important from a practical standpoint, and therefore for our use the scientific nomenclature of rocks can scarcely be improved. This nomenclature differs but slightly from that in common use, and this is due to the circumstance that the old popular names given by miners and quarrymen to ores and stones have always been used in mineralogical and geological studies. The great variety of practical applications which these studies find in the arts has rendered difficult and impracticable the introduction of such a system of generic and specific names as characterizes the more modern sciences, which are not so directly applied in common life; but it is noticeable that many old names, like trap, greenstone, lava, etc., which still are used in the popular nomenclature, have long since been banished from scientific works as meaningless.

The earth is covered with hard rocks and the loose products of their disintegration. If the hard rocks have resulted from a cementation and consolidation of what once was loose material, they maintain the stratified character of the original bed. When heat, moisture, or any other agencies have rendered them very compact and resistant, they still retain some traces of their original stratified character; and whenever it can be shown that a given rock was once composed of those loose products of the disintegration of older rocks, it is called stratified. The different members of the stratified group of rocks are often very unlike one another. They are sometimes composed of merely cemented masses of sand or pebbles, and their origin is very plainly seen: at other times the original constituents and the original structures are both nearly obliterated by subsequent processes of modification. Their stratification is in some cases very plain, and modifies the processes which are used in quarrying and in dressing the stones, as well as the uses to which they are applied. In other cases the stratification is with difficulty detected, and shows itself only when large masses of the stone are seen, or in the greater ease with which the stones are worked in given directions.

The process of cooling from a molten state, through which the earth has passed, has necessitated a constant change of volume and consequent strain upon its crust. Thus in every age of the world's history clefts have been formed through which materials have issued in molten condition from the interior of the earth, and have been poured forth in greater or less quantity upon its surface. Such materials cooling from a molten condition do not possess stratification, but are massive and crystalline. The modern volcanic rocks belong to this class; some of these are light, porous rocks, which are easily worked and are much used in countries where they abound. They are not employed to any extent in the United States, because there is little construction in those regions where they are abundant. The older granitic rocks of this class are hard, compact, and durable. Mechanical forces which have acted upon their surfaces for long ages have worn down and removed any soft and porous material which might have existed. They are quarried with more difficulty, and consequently are not so extensively employed as the sandstones and the limestones of the stratified group, but they possess such properties as make them favorite materials of construction. In general, the sedimentary and the volcanic rocks possess structures that render them more easily cut and worked, while the ancient massive rocks are more hard and durable. The ready accessibility of the granitic rocks in the most thickly settled portions of America has caused them to be more extensively used among us than in any other country in proportion to the amount of stone construction.

These considerations divide rocks into two principal groups, each of which may be subdivided. The further subdivision depends upon the mineralogical composition of the individual stones, as is indicated in the following classification.

If this classification is rigidly adhered to, numbers of rocks which are related by those physical properties that determine the uses to which they are applied are quite widely separated from one another. Gneiss, for example, is so much like granite that it is often used in the same way for the same purposes. The rocks which are related in composition are conveniently grouped together as being the material of one and the same industry, even though their mode of origin is recognized as different.

The following tabulation forms the basis for comparison of the industries considered in this work, and for convenience a name is given to each group, which is either that of its predominant member or that by which the stones that compose it are commonly known:

1. Granite.
   Syenite.
   Gneiss.
   Crystalline schists.
   Diabase.
   Diorite.
2. Fragmental rocks (sandstones).
   Siliceous sandstones.
   Feldspathic sandstones.
   Conglomerates.
   Breccias.
3. Carbonates (limestones).
   Common limestones and dolomites.
   Crystalline limestones and dolomites.
   Shell limestones.
   Calcareous tufa.
4. Serpentine.
5. Slate.

In this report, then, the rocks at present used for purposes of construction in the United States are for convenience divided into the following classes:

1. Crystalline siliceous rocks.
2. Sandstones.
3. Marble and limestones.
4. Serpentine.
5. Slates.

Rocks popularly known as marble and limestone are classed together, owing to the difficulty of drawing a definite line between the two; all distinctively calcareous rocks are included in this table.

The group headed "Sandstone" comprehends all the siliceous rocks not included in the tables of the crystalline siliceous rocks and serpentine. Materials commonly known as sandstone, freestone, flag-stone, some of the so-called "blue-stones", quartzite, and all the conglomerates, except the calcareous conglomerates, come under this heading.

In the class of crystalline siliceous rocks are placed those popularly known as granite, syenite, gneiss, mica-schist, trap, basalt, porphyry, and volcanic rocks.

Serpentine was quarried during the census year, to a sufficient amount to admit of tabulation, only in Pennsylvania, and even here the product was small as compared with that of previous years. The greater part of the slate product tabulated has been used for roofing, though a portion of it was employed for sidewalk paving, tiling, and other purposes of construction.

States and territories wherein any one of the classes of rocks above described are not quarried for purposes of construction are, of course, omitted in the tables devoted to that particular class, though many states and territories are rich in the undeveloped material.

DECOMPOSITION OF STONES.

There are many more factors which determine the value of stones for purposes of construction than are often considered in the elementary treatises upon this subject, and the rules laid down are often determined by the local circumstances. A more extensive study of building stones frequently vitiates the rules which apply in limited areas. It is, for example, stated that, in order to determine whether a stone will withstand the action of the weather, one should visit the quarry and observe whether the ledges that have been exposed to the weather are deeply corroded, or whether these old surfaces are still fresh. This is not a fair criterion, because the applicability of such a test is modified by geological phenomena. North of the glacial limit all the products of decomposition have been planed away and deposited as drift formation over the length and breadth of the land. The rocks are therefore in general quite fresh in appearance, and possess but a slight depth of cap or worthless rock. The same classes of rock, however, in the south are covered with the rotten products resulting from long ages of atmospheric action. They may be rotten to great depths, and the removal of the worthless rock is often difficult. This is due to the circumstance that no agencies have here operated to scrape off and remove the loose material from their surfaces in recent geological time.

There are other peculiarities of decomposition regarding which too absolute rules have been laid down. Pyrites is considered to be the enemy of the quarryman and constructor, as it decomposes with ease and stains and discolors the rock. But here, too, there are features which very seriously modify the effect of this decomposing substance. Pyrites, in sharp, well-defined crystals, sometimes decomposes with great difficulty. If a crystal or grain of pyrites is embodied in soft, porous, light-colored sandstones, like those which come from Ohio, its presence will with certainty soon demonstrate itself by the black spot which will form about it in the porous stone, and which will permanently disfigure and mar its beauty. If the same grain of pyrites is situated in a very hard, compact, non-absorbent stone, the constituent minerals of which are not rifted or cracked, this grain of pyrites may decompose and the products be washed away, leaving the stone untarnished.

We believe that the microscopic study of these stones is, even in such simple cases as this, necessary for a correct determination as regards the influence of decomposing agents upon the stone.

Again, some of the constituent elements of rocks are so frequently found in a decomposed condition that they are considered to be deleterious, when present in large quantity, on account of their well-known tendency to decompose. For example, olivine indicates a very marked tendency to decompose, as indicated by the vast accumulations of serpentine which are so frequently found to be a result of its decomposition; but the circumstances which in past time have brought about this decomposition may have been very different from those which are at present active, and the prejudice against olivine in a rock is not supported by any observations which indicate that it will decompose under the present influences. We wish to bring prominently forward that we consider that a decision as to the probable action of the agents producing decomposition in rocks should be largely dependent upon careful microscopic examination of the structure of the rock. Our experience has demonstrated that a rock of a given character, as regards ultimate composition and mineral constituents, may be easily affected by the weather if its constituent minerals, as indicated by their microscopic structure, are so fractured that they are laid open to atmospheric agencies through rifts, no matter how small, while the same stone, with the same constituents, may be eminently resistible to decomposing agencies if its constituent minerals are sound, whole, and impermeable, as indicated by the microscopic structure.

In the old world, where immense cathedrals, planned long ago, have been in the process of construction for hundreds of years, it has not been uncommon to see portions of the building fall into decay before the structure was finished, and the process of restoration often consumes large sums of money while the process of construction is yet going on. It thus very frequently happens that a variety of stones is used in the construction of the same building, because in this process of construction experience is gained indicating inapplicability of the stones used for durable structures. In this case it is experience alone which finally dictates the most suitable material; and even to this day, here in America, there is no other criterion to apply to a building stone save the test of experience; and the result is that buildings can be pointed to which, like those old, immense structures before referred to, are already crumbling while yet in the process of construction.

PRESERVATION OF STONES.

Disintegration of stone and the method by which this can be arrested has furnished a topic for considerable study. The methods which have been applied with most success are to bathe the stones in successive solutions, the chemical actions between which bring about the formation of insoluble silicates in the pores of the stone. For example: If a stone front is first washed with an alkaline fluid to remove dirt, and this subsequently followed by a bath of silicate of soda or potash and allowed partially to dry, and then bathed again: and if the surface is then bathed in a solution of chloride of lime, chlorate of sodium or of potassium, according to what is used, an insoluble lime silicate is formed. The soluble salt is then washed away and the insoluble silicate forms a durable cement and checks the disintegration. If lime water is substituted for chlorate of lime there is no soluble chlorate to wash away.

INFLUENCE OF CLIMATE.

In addition to the consideration of the humidity of the atmosphere, the influence of the purity of the atmosphere is also important in deciding on a building material. For example, in the smoke of Pittsburgh it would make very little difference what the material employed for construction might be, so far as appearances are concerned, since it would soon assume the gray color peculiar to all the buildings of the city; but the capacity of a stone to resist acid vapors would become very important, since the only point necessary to be considered in selecting a stone would be as to whether ornamental structures are defaced and disintegrated by the vapor fumes peculiar to this atmosphere.

STRENGTH OF MATERIALS.

In practice it is not common to place stones where they are obliged to bear more than one-sixth or one-tenth of the weight which their crushing strengths, as determined by experiments, indicate that they are able to bear. Beside this, there are many considerations which demonstrate that reliance upon experimental data is unsafe. A stone that will crush under a given pressure to-day may, if exposed to the weather, crush under a very much smaller or very much larger weight after the passage of years, according to the action of the weather upon it. Stones, when they crush, usually break in certain lines of weakness, which lines may be arbitrarily situated in the stone and difficult to detect, or may be definitely situated and dependent upon structure. As stones from different parts of the same quarry, and even from different places in the same layer, frequently vary greatly in strength, it is quite important to develop methods by which the strength of stones and their variability in this respect can be more easily detected than by the laborious experimental tests upon small cubes. Results of studies made upon the structure and composition of those stones which have been very accurately tested as to their strength are valuable contributions in this direction.

Chapter II.—MICROSCOPIC STRUCTURE.

By G. P. Merrill.

It is not the intention in this chapter to present a purely scientific treatise on microscopic lithology, but rather to give a short description such as together with the plates will enable any one with but a slight knowledge of the subject to appreciate the variations in structure and mineral composition of some of the more common kinds of building stones. What may be considered as typical specimens of the various kinds of rock quarried have been selected, and from the thin sections, prepared as already described, enlarged photographs have been made from which the plates have been reproduced. They therefore show the exact structure as seen under the microscope, excepting, of course, in the matter of color. In preparing the text the manuscript notes left by Dr. Hawes have been utilized so far as possible.

THE CRYSTALLINE SILICEOUS ROCKS.

Rocks that are commercially designated as granites are composed in some cases of minerals which are entirely absent in other rocks that are also designated as granites. For example, some of the so-called black granites are diabases or diorites. But the circumstance that the minerals, although different, are all very nearly of the same hardness; that the rocks therefore offer the same difficulties in cutting, in dressing, and in polishing, and that the similarities of their appearance render them applicable to like purposes, unite these rocks into a well-defined group. In it are included the various granites, syenites, trap-rocks, gneisses, and crystalline schists.

The structural differences that exist among the rocks of this class, although indicating very different modes of origin, are fully recognized in grouping these rocks thus together.

The nomenclature for these rocks in use among quarrymen shows that they are all related as economic products; for example, the gneisses are frequently called "bastard" granites or "striped" granites, as are also frequently the mica-schists. The trap-rocks, where they are quarried, are very commonly called "black" granites or "gray" granites, and as a rule no distinction whatever is made between the granites and syenites. Therefore, in a tabulation which shall indicate the extent to which the hard crystalline rocks are quarried, and shall give the data for comparing one well-defined industry with the others, these rocks are naturally associated together.

Although, as shown, these rocks do possess common characters that unite them into a well defined group, they possess differences which allow the group to be subdivided both according to the appearances and uses of the stones. The granites and gneisses, for example, possess the common characters already referred to, but the resemblance extends no further. It is therefore a positive disadvantage to the industry to classify them, as is so frequently done, under a common name. Therefore, in the tabulation the common name by which the stones are sold will be given, accompanied by the scientific designation.

These rocks are found chiefly among the older formations and in regions where there have been such disturbances as have cleft the crust of the earth and given egress to the fused matters which underlie it. The crystallization of these molten materials which have thus been erupted has given rise to many of the rocks which, on account of their massive homogeneous structure, are most prized. Quarries of these rocks occur in all the Atlantic states, the Lake Superior states, and in the mountainous regions of the far west. Thus the great interior basin of the continent is left without rocks of this class, if we except some isolated areas in Missouri, Arkansas, and Texas.

It is not, however, to be inferred that all of the rocks of this group are as old as the rocks which characterize these regions. The gneisses and the crystalline schists are very old rocks, belonging mostly to the Archæan period. The other members of the group are eruptive rocks which have at some period in the earth's history been molten, and have been forced through clefts in these older rocks. There is, therefore, no method of determining their exact age in all cases, since the time of their eruption can only be determined as being later than the time when the rocks which they intersect were accumulated. It is, however, known that a great many of them are very old, and that the time of their eruption was probably identical with the elevation of the mountains and the disturbances which would have naturally resulted in producing the clefts through which they were erupted; and it is also known that some of them are quite modern in age, since they intersect sandstones which were accumulated in later periods of the earth's history.

GRANITE.

The essential components of the true granites are quartz and potash feldspar. Although the essential minerals are but two in number, the rocks are rendered complex by the presence of numerous accessories which essentially modify the appearances of the rocks and those properties which render them of importance as building stones. These additional minerals are either present in such amount as to be conspicuous and to exercise an influence upon the appearance and structure of the rock, when they are called characterizing accessories, or they are present in such small amount as to be invisible to the naked eye, when they are called microscopic accessories. If all the minerals which by careful examination have been found in granites should be considered as constituents of the rock, then the latter would appear as very complex. At least two-thirds of all the known elements exist in granitic rocks, and the number of minerals that are liable to be present in special cases is very large.

The following list does not include all of those minerals which have been identified in this rock, for many have been found under circumstances which are so isolated that their occurrence is entirely exceptional. All of the minerals in this list are liable to be found at any time, and may therefore be considered as common constituents of the rock, although the presence of them all together is not to be expected, and some of them may be present in such minute amount as to be of no practical importance. Any one of them, save the two essential constituents mentioned above, may be absent from an individual specimen, or from a granite from a given locality; and any one may be present in the specimens from a given locality in such amount as to give a character to the rock. Thus almost any one of those minerals which are given as microscopic accessories may assume the character of a characterizing accessory; this is especially true of the iron oxides, which sometimes are present in such amounts as to become characteristic:

Essential:
- Quartz.
- Feldspar.
  - Orthoclase.
  - Microcline.
  - Albite.
  - Oligoclase.
  - Labradorite.

Characterizing accessories:
- Mica.
  - Muscovite.
  - Biotite.
  - Phlogopite.
  - Lepidolite.
- Hornblende.
- Pyroxene.
- Epidote.
- Chlorite.
- Tourmaline.
- Acmite.

Microscopic accessories:
- Sphene.
- Zircon.
- Garnet.
- Danalite.
- Rutile.
- Apatite.
- Pyrite.
- Pyrrhotite.
- Magnetite.
- Hematite.
- Titanic iron.

Decomposition products:
- Chlorite.
- Epidote.
- Uralite.
- Kaolin.
- Iron oxides.
- Calcite.
- Muscovite.

Inclosures in cavities:
- Water.
- Carbon dioxide.
- Sodium chloride (salt).
- Potassium chloride.

The feldspar, which is so easily recognized by its cleavage surfaces in all of the granites, is by far more complex in composition than has usually been supposed. It is exceptional to find a granite which contains but one kind of feldspar, and not merely are two or three species usually present, but the structure and condition of their crystals are far from simple. The potash feldspar sometimes exists in the form of orthoclase and sometimes in the form of microcline. Microcline is a feldspar of the same composition as orthoclase, but differs from it in crystalline form by belonging to the triclinic system, which possesses no right angle. The orthoclase is very commonly seen in crystalline grains, in each of which one-half bears the relation to the other half of one crystal revolved 180° about an axis in another. Such are called twin crystals. They render themselves conspicuous to the eye in some granites by the different positions in which one receives the bright reflections from the two sides. The microcline is divided

into such a multitude of twinned parts that they are only recognized by a microscopic examination, and in addition two different systems of twinning combine to make the structure more complex. Therefore, in the thin sections, while the orthoclase at the most is divided into two parts by a straight line, the microcline as seen in polarized light possesses a reticulated structure, which is due to the interweaving of the multitude of lamina that stand in the relation to one another of twin crystals. This structure will be noticed in the plates.

The discovery of this species of feldspar has been one of the developments of microscopic mineralogy, and examination has proved microcline to be one of the prominent constituents of granites.

The albite, oligoclase, and labradorite are identified in thin sections by the circumstance that they possess also a complex twinned structure; but one system of twinning preponderates, so that they possess a banded structure which evinces itself in the fine parallel striation that is frequently seen on its bright cleavage [illegible]s with the unaided eye, and in thin sections the same is much more plainly shown by the banded structure that its sections possess in polarized light when the crystals are cut in some plane that is not parallel with the plane of the lamination. The optical properties of the individual species render it possible to still further identify them; or they may be analyzed when it is possible to separate them from the rock.

The different kinds of feldspar that exist in these granites are sometimes separated from one another in distinct grains, and sometimes are interlaminated with one another, forming complex grains. For example, orthoclase and albite are frequently combined in the same crystal or grain.

All of these circumstances of composition and structure are important, for the appearances of granites depend largely upon the feldspathic ingredient. The different species are often quite differently colored, and thus at times a beautiful mottled appearance is imparted to the stone; if, for example, the orthoclase feldspar is red and the albite or oligoclase is white, the effect of this mixture of colors is strikingly manifest. If both kinds of feldspar are white, one may be opaque and the other transparent, or one may be opalescent and the other dull. In general, many of the most striking characteristics and a large proportion of the immense diversity in granitic rocks are due to this complexity in the feldspathic constituent, and its consideration is one of the most important elements of their study.

The feldspar has also an influence upon the cutting of the stone and its shade of color. The so-called hard granites consist of quartz with a compact, transparent, nearly glassy feldspar, which is quite difficult to cut, and which allows the light to enter it and be absorbed, thus imparting to the stone a dark color, as in the case of the Quincy granite. The cause of the hardness of these rocks is not entirely due to the quartz, as is often supposed Quartz is always brittle, and is not very variable under tools. The hardness of hard granites is due to the condition of their feldspathic constituent, which is variable. The soft granites, however, consist of the same constituents, but the feldspar is porous and is thereby rendered soft and less resistant to the tools. The light is reflected under these circumstances from the surface and the rock is rendered white. It bears the same relation to the feldspar of the hard granites as does the foam of the sea to the water, but of course in a less marked manner. The Concord granite may be mentioned as an example.

The structure of the feldspar modifies the resistibility of the stone to decay, the quality of the polish which may be imparted, and the ease or difficulty with which the stone may be discolored or stained.

The quartz is much more simple in structure, and is subject to many variations in form and appearance, but to none in composition.

Although belonging to what we call the infusible substances, it is evident that in the solidification of the granitic rocks such agencies were active as rendered this substance more easily fusible than the other ingredients, and it was therefore the last element to take final form in the solidification. This is shown by the way in which it occupies the interspaces which were left after the other minerals had crystallized, and it therefore, to a certain extent, acts as a kind of cementing material to the other ingredients. Some granites contain large, imperfect quartz crystals, which must have been one of the first products of the solidification, but in nearly all granites the last substance to solidify is the quartz.

The microscope indicates that the quartz almost always contains pores which are partially filled with fluids. The number and size of these pores are of considerable importance, as they tend to explode when heated, and this aids to disintegrate the rock at a high temperature. It is important to note, however, that the various minerals which compose granites possess different expansibilities, and this is a cause of the well-known tendency of granites to disintegrate in the fire. Granite usually contains about eight-tenths of one per cent. of water, and is capable of absorbing a few tenths more. The water permanently present is largely contained in these pores when the rocks are fresh, and the capacity for further absorption is due to the rifts and empty pores that are largely confined to the feldspar.

At times quartz and feldspar constitute almost the whole of the rock, and at other times the accessories become very prominent. These accessories vary with the locality, and give the characteristics to the various kinds.

Mica is the most common of the accessory ingredients, and its presence constitutes what is called mica granite. If the mica is the white muscovite, the granite may be very light in color and may be almost white, as in the case of the Hallowell granite, or the granite from Barre, Vermont. If the mica is exclusively the black variety of

biotite, the granite will be dark in proportion as this mineral is present. If both species are present, as is frequently the case, the granite will be speckled with alternating black and white shining spots, as in the case of the Concord granite.

The amount of the mica present is economically important. It does not polish as easily as do quartz and feldspar, owing to its softness, and the presence of a large amount therefore renders the rock difficult to polish. When polished it does not retain its luster so long as do the other minerals, and its surfaces become dulled by exposure. Its presence in large amount is therefore deleterious to stones which are intended for exterior use as polished stones. The condition in which it exists is also important in this respect. A large amount of mica scattered in very fine crystals through the rock influences its value as a polished stone less than does the presence of large and thick crystals of mica scattered through the rock in smaller number. The method of arrangement of the mica is very important: if scattered at haphazard, and lying in all directions among the quartz and feldspar crystals, the rock will work nearly as easily in one direction as in another. If it is distributed through the rock in such a manner that its laminæ are arranged in one definite plane, it imparts a stratified appearance to the rock, and when this stratified appearance becomes marked, the stone is called gneiss. One or two causes may give rise to this structure, but so far as it exists in granites it is easily explained by the circumstance that slight motions in a given direction in a plastic mass will cause all of the flat and long constituents to arrange themselves in a definite plane. If, for example, some mica scales or any other thin flat scales are mixed in clay so that they lie scattered through it in all directions, and if this clay is pressed so that it is flattened out a little, a section through the clay will show that the scales have arranged themselves in a definite plane, an effect produced by the motion of the plastic mass induced by pressure.

As granite is supposed to have cooled from a condition of fusion, the circumstances must plainly have existed under which this laminated structure could have been produced, for the mica was crystallized before the rock was entirely solid, as is evident from an examination of its microscopic structure, which shows that the mica invariably crystallized before the quartz had taken form. The effects of the parallel arrangement of minerals in granites are often evident, even when this arrangement is invisible to the unaided eye. Apparently massive granites cleave more readily in one direction than in another, and this plane of more easy cleavage is always detected by quarrymen with experience.

If hornblende is the characterizing accessory, the granites are usually without any evident stratification, as this mineral exists in the granites in granular form. Hornblende is subject to as wide variations of composition as is mica, but its white and very light colored varieties do not frequently appear in the granitic rocks. Its green varieties occur and give a characteristic shade of this color to the stone, as is illustrated, for instance, in the granite of which the new Mormon temple is built. It cleaves parallel to two planes which make an angle of 124° with each other, and is thus distinguished from mica, which invariably has but one cleavage. It is easier to polish than mica, and its presence is favorable on this account. The hornblende granites are to be classed among the best.

Pyroxene as a characterizing accessory in granites is more abundant than has usually been supposed. Indeed all rocks which contain pyroxene abundantly have usually been confounded with the hornblende granites. The distinction between pyroxene and hornblende is important from an economic standpoint, as hornblende possesses a much better cleavage than pyroxene, while the pyroxene is much more brittle than hornblende, and cracks out with greater ease in working. The cracking out of little pieces from the black ingredient of the Quincy granites has been frequently noticed, and is due to the circumstance that this granite is not the hornblende granite that it has been usually supposed to be. Hornblende is very tough, but the Quincy granite contains a peculiar variety of pyroxene, which is so brittle that it is difficult to make a large surface on a Quincy granite which does not show some little pits, due to the breaking out of a portion of the black grains of pyroxene.

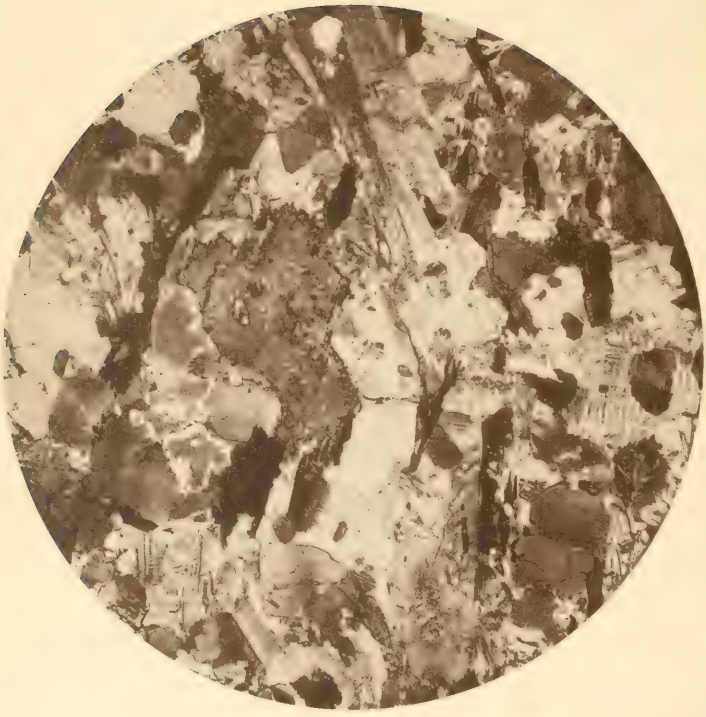
Although pyroxene and hornblende may be identical in composition, they are frequently associated together in the same rock, a circumstance which is very evident in thin sections, but not in the massive stones. The rocks which contain hornblende also frequently contain mica, but it is noticeable that under such circumstances the mica is always of the dark-colored variety, and an example of a granite which contains both hornblende and muscovite is not known.

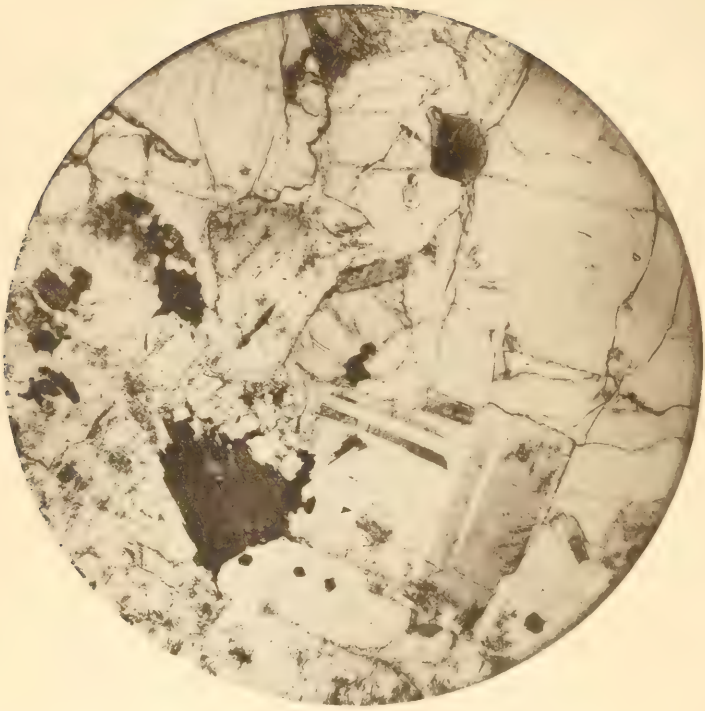
Epidote is quite characteristic when present in the granite, giving to it its deep green color. Its crystals are always green so far as observed in granite, and the polishing of the stone develops the brightness of this color. It is sometimes an apparently original constituent of the rock, and at other times a decomposition product.

The Dedham, Massachusetts, granite is one of the most marked examples of an epidotic stone. It is also frequently present in all the varieties of granite previously mentioned, and more or less modifies their appearances.

The tourmaline granite usually occurs in veins of inconsiderable size. Such granites are associated with those that are extensively worked, and in themselves are often beautiful, but they do not exist in accumulations of such size as to warrant the opening of quarries to work them exclusively. The tourmaline granites must, therefore, be considered as accessory products that exist in connection with the quarried stones, but which are not extracted for economic purposes.—G. W. H. [a]

[a] The chapter to this point is from Dr. Hawes' notes.





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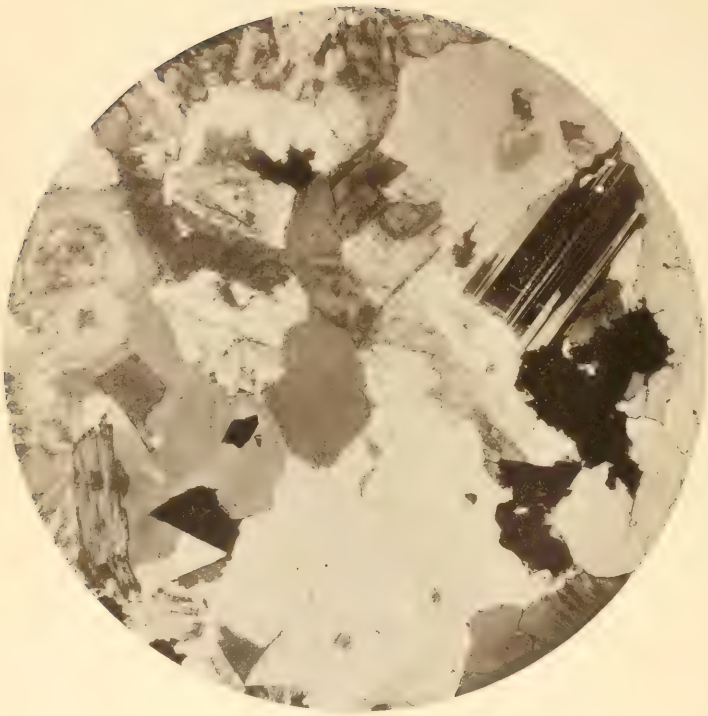

Sullivan, Me.

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The granites at present quarried throughout the United States may be classified as follows:

Muscovite granite.
Biotite granite.
Muscovite-biotite granite.
Horneblende granite.
Hornblende-biotite granite.
Epidote granite.
Granitell, or granite without any accessory.

Although it is possible to classify all the granites under these heads, the lines of distinction between them are by no means sharply drawn, but the different varieties merge into each other by continual gradations. For instance, nearly all the muscovite granites contain a little biotite, and *vice versa;* also, nearly all the hornblende granites, as those of cape Ann and other localities, contain some mica, although not in all cases enough to be visible without the aid of the microscope. In these cases the dividing line must necessarily be drawn somewhat arbitrarily, and it is the prevailing accessory which has given the specific name to the rock; or when two are present in such abundance as to be both evident to the naked eye, then the two descriptive names are employed, as in the case of the muscovite-biotite granite of Concord, New Hampshire, which contains both micas in nearly equal proportions.

MUSCOVITE GRANITE.

Since muscovite itself is very nearly colorless, the granites bearing this mica as their chief accessory are very light in color, being in fact the lightest of all our granitic rocks. Pure muscovite granites are not at present extensively quarried. That found at Barre, Vermont (*see* Plate I), is a coarse, light gray rock of almost marble whiteness, a polished surface of which presents a somewhat mottled appearance due to the presence of quartz and mica. The prevailing constituents are quartz, orthoclase, plagioclase, and white mica or muscovite. When examined in thin sections under the microscope the interstices between the larger crystalline grains are found to be filled with very many smaller grains of quartz and feldspar, together with shreds of mica and numerous accessories, giving rise to the structure known to lithologists as "drusy".

The mica as seen in ordinary light is quite colorless, but between crossed Nicol prisms it gives a most beautiful iridescence. It occurs usually in ragged shreds, but rarely in small forms with definite crystalline outline. A very little biotite is also present. The feldspars are the predominating minerals and occur in more or less perfect crystals, while the quartz grains fill the interspaces. The chief accessory mineral in this rock is epidote, which occurs in small irregular grains without definite crystalline outlines and is traversed by numerous fractures. In the thin sections it is of a very faint greenish color. Some apatite is also present in the form of small, colorless, six-sided crystals, which are never large enough to be visible to the naked eye.

A fine gray muscovite granite of a slightly darker shade, though much more even in texture, is quarried near Atlanta, Georgia. This rock is richer in both quartz and mica than its representative from Vermont, but contains less epidote. A large part of the feldspar of this rock is microcline, as is shown by its peculiar reticulated structure when viewed in polarized light.

BIOTITE GRANITE.

This constitutes the most widespread group of our granitic rocks, and presents also the most diversified color and structural peculiarities. A large proportion of all the granites at present quarried in the United States is referable to this group. In color they vary from light to dark gray and almost black, according to the amount of mica they contain and the color of the feldspar; the red granites, many of which belong here, owe their color to the flesh-red orthoclase, which is the prevailing ingredient. As a general thing these granites are much tougher and harder than those of the preceding group, and, if we except the porphyritic varieties, possess a more even texture, lacking the drusy structure characteristic of muscovite-bearing rocks. The texture, however, varies almost indefinitely, and it is obviously impossible to select rocks from any one locality as typical for the group. Perhaps the more common varieties are those represented by the granites from Dix island, Maine, Westerly, Rhode Island, and Richmond, Virginia.

The essential constituents of biotite granite are quartz, orthoclase, and biotite, but a plagioclastic feldspar is almost invariably present, together with some magnetite and apatite. The usual accessories are microcline, hornblende, muscovite, apatite, epidote, sphene, and zircon. It is stated by Rosenbusch (*a*) that the biotite granites, as a class, usually contain less quartz and a correspondingly larger proportion of plagioclase than those of the muscovite-bearing group.

As representatives of this group Plates II and III are given from sections of the granites from Dix island and Sullivan, Maine. These are both coarse, gray rocks, containing a considerable proportion of plagioclase in connection with the orthoclase. The biotite in thin sections is of a yellowish-brown color and bears numerous inclosures of apatite and magnetite. The pores in the quartz of these rocks are neither abundant nor large; in the Dix Island granite they are often arranged in fine wavy lines traversing the quartz grains in directions nearly parallel to one another.

a Mikroskopische Physiographie der Massigen Gesteine, p. 20.

The biotite granites from Manchester, Virginia, and vicinity are practically of the same constitution as these, although differing in details of texture. Small zircon crystals and scattering flakes of muscovite, together with a few garnets, are found in these rocks.

The granites of Westerly, Rhode Island, are biotitic, but differ from those just mentioned in being usually of a finer texture and more rich in accessory minerals, containing frequently small crystals of fluor spar, sphene, menaccanite, magnetite, apatite, epidote, and pyrite; the quartz contains also many of the small, thread-like crystals so characteristic of rutile. Many of the Westerly granites are of a flesh-red color, but otherwise than this they do not differ materially from the ordinary gray granites, the red color being as usual due to the red orthoclase they contain.

The red granites quarried at Red Beach and at Jonesboro', Maine, have biotite as their characterizing accessory. These are coarse, compact rocks of even texture, and tough and hard. They bear but few accessory minerals, a little apatite and magnetite only being observed. The mica occurs usually in small ragged shreds of a greenish color.

The red granite quarried at Lyme station, Connecticut, differs from the last in being of a still coarser texture, and in the feldspars occurring in beautiful large glassy crystals. The proportion of plagioclase is much larger than in the Maine red granites, and it contains little if any apatite and magnetic iron. The quartz contains numerous quite large pores or cavities, in many of which moving bubbles were noticed, while in others the bubbles were motionless.

The Leetes Island and Stony Creek red granites are of a much lighter shade than those of Lyme, the feldspars being only light pink or flesh red in color, and of a more gneissoid structure. Some muscovite is present, together with the biotite and a little epidote; the quartz contains but few cavities. A part of the Leetes Island rock has a porphyritic structure, and is of a mottled pink and gray color, due to the larger pink feldspar crystals being surrounded by a finer admixture of small grains of quartz and mica.

A coarse red granite is quarried in the vicinity of Iron Mountain, Missouri, a part of which differs from any of the preceding in containing no characterizing accessory, to the unaided eye the stone appearing to consist only of quartz and feldspar. Under the microscope a few grains of magnetite are visible, as well as a few scales of hematite. Other granite from this locality contains black mica, which is usually more or less altered into chlorite. A red granite comes from Burnet county, Texas, which is of a fine, even texture, and contains much plagioclase. So far as observed this stone is lacking in tenacity, but this is very probably due to the fact that the quarries have not yet been worked to sufficient depth to bring to light the better portions of the rock, the feldspars showing signs of decomposition such as are produced by weathering.

The red biotite granite from the government quarries at Platte cañon, Colorado, is much coarser than the last, and contains many blood-red scales of hematite. The biotite is very dark and opaque.

So far as observed, all our porphyritic granites are biotitic. A part of the East Bluehill (Maine) rock is a beautiful example of this variety. This is a fine dark-gray rock, the uniformity of whose texture is broken by a plentiful sprinkling of snow-white orthoclase crystals of an inch or more in length, the crystals being usually in the form of Carlsbad twins. In many of the East Bluehill rocks the biotite is found altered into a chlorite, in which case it contains numerous inclosures of magnetite. Muscovite is also frequently present in small quantity, together with the usual colorless apatite crystals.

MUSCOVITE-BIOTITE GRANITE.

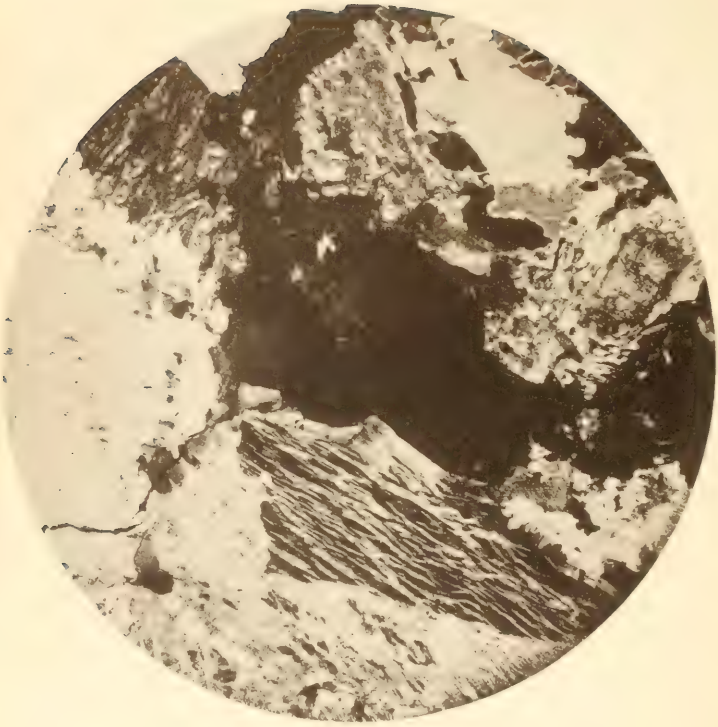
As its name denotes, this variety combines the properties of both muscovite and biotite granite, and may be considered as intermediate between the two. Transition stages between this and true muscovite or biotite granite are continually met with, and, as already stated, no sharp line of distinction can be drawn between them. The essential constituents are quartz, orthoclase, muscovite, and biotite; small transparent crystals of apatite are nearly always present, together with more or less plagioclase; zircons occur quite rarely.

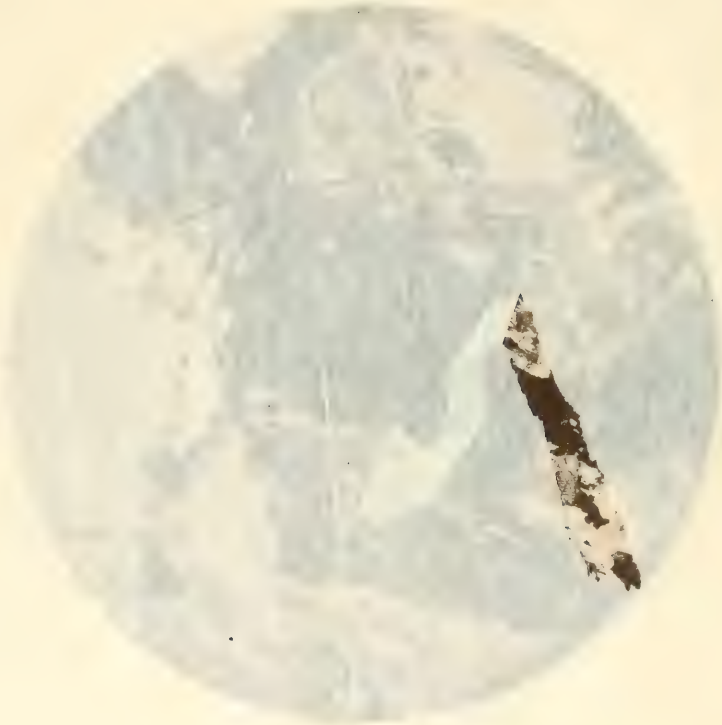
Of this variety, the so-called Concord (New Hampshire) granite may be considered as typical. It is a fine-grained, light-gray rock, showing under the microscope a somewhat drusy structure. The feldspars are in nearly every case more or less turbid through decomposition and impurities, while the quartz is penetrated in every direction by small needle-like crystals of rutile. Fluidal cavities are quite small and not at all abundant. According to Dr. Hawes, (*a*) the plagioclase of this rock is oligoclase; some microcline is also present. The micas usually occur in small, irregular flakes, without definite crystalline outline, but occasionally a small, perfect crystal of muscovite can be seen.

Between the Concord and the lighter colored of the Fitzwilliam granites there is no essential difference. Microscopic particles of zircon were found in the Fitzwilliam rocks, which were not noticed in those of Concord.

The granites quarried at Allenstown, Sunapee, and Rumney offer no differences of practical value. As a general thing they are much like the Concord, presenting only slight variations in the way of color and texture. The feldspars as seen by the microscope are sometimes in a little fresher state and contain fewer impurities, while the quartz usually contains less rutile, that from Rumney having none at all, and fluid cavities are perhaps a trifle more

a Min. and Lith. of N. H., p. 194.





abundant. The Manchester granite differs from any of the preceding in being of coarser texture, with a flesh-red color, and containing very little biotite, but a much larger proportion of microcline. The quartz frequently contains small colorless crystals resembling fibrolite; brilliantly red scales of hematite are also occasionally met with, as well as many large opaque grains of magnetite.

Outside of New Hampshire, muscovite-biotite granite is quarried quite extensively at Ryegate, Vermont, and at North Jay, Lincolnville, and Hallowell, Maine. The Ryegate rock is of coarser, more even texture, and contains a larger proportion of quartz than that of Concord. The quartz is almost entirely free from rutile inclusions and the feldspars are in a very pure condition, in both of which respects it closely resembles the Jay rock. The Hallowell and Lincolnville granites resemble the Concord closely, both in color and in structural peculiarities, even to the presence of the rutile inclusions. It contains, however, a much larger proportion of the feldspar microcline. A few garnets unobserved elsewhere are present in the Hallowell rock.

A rather coarse biotite-muscovite granite is quarried near Fredericksburg, Virginia. The feldspars in this rock are quite impure and frequently contain numerous inclosures of muscovite. Microcline is quite abundant in this rock, as is the case also with that of Hallowell and Augusta, Maine.

HORNBLENDE GRANITE.

As has already been stated, no sharp lines of separation can be drawn between the different varieties of granite, and in no case is this better illustrated than in those rocks bearing hornblende as their chief accessory, nearly all of them containing more or less black mica. This is well illustrated in the case of the granite quarried at Gloucester, Rockport, Lynnfield, and other localities in Massachusetts. From specimens of these rocks forwarded to the Museum it appears that while with one or two exceptions they would, from a simple macroscopic examination, be classed as hornblende granites, the microscope shows a constant gradation from those in which biotite is easily distinguishable in the hand specimen to those in which apparently there is none, more or less mica appearing in all. The distinction must, therefore, be somewhat arbitrary, and only those have been called hornblende granites in which no biotite was visible to the naked eye. (*a*)

As typical of this group, Plate IV is given. It is from a magnified section of the rock quarried at Peabody, Massachusetts. This rock, which agrees so closely with that quarried at the other localities named that a single description will do for all, is a coarsely crystalline rock composed essentially of quartz, orthoclase, and hornblende, the orthoclase being frequently of a faint greenish or bluish tinge, while the quartz varies from light glassy to dark smoky tints. The rock is of quite uniform texture, exceedingly hard and tough, and may be ranked as one of our most durable granites. Under the microscope it is seen that the feldspar of this rock is nearly all orthoclase in a very fresh and undecomposed condition, and as orthoclase is the hardest and toughest of all the feldspars the predominance of this variety over all others easily explains the hardness of the rock. In none of the granites quarried during the census year are the plagioclastic feldspars entirely absent, though sometimes prevalent in very minute quantities, as is well illustrated in the hornblendic granites of Gloucester, Roxbury, Lynnfield, Peabody, etc., and especially in that of the last named locality, where it exists only as minute microscopic crystals, filling the interspaces between the larger crystals of orthoclase. The quartz, which is quite abundant, contains the usual cavities, in some of which moving bubbles occur. The hornblende is of a deep green, almost bluish, color, and never occurs in perfect crystals, but rather in broken fragments and ragged shreds bearing numerous inclusions of apatite and zircon. Zircon is especially abundant in the Gloucester granites, where it occurs usually in small, square prisms scattered irregularly about or clustered around the ragged edges of the hornblende crystals. Some magnetite is usually present, and an occasional shred of black mica.

A very beautiful deep-red hornblendic granite is quarried at Otter creek, Mount Desert, Maine. It is a very compact rock, though not quite as tough as those from cape Ann. Under the microscope the feldspar is found to be quite opaque through impurities. The hornblende is deep green, nearly black, and some chlorite and apatite are present, together with quite large epidote granules and a few zircon crystals.

Two varieties of hornblende granite, one red in color and the other gray, are quarried at Saint Cloud, Minnesota. They differ, however, from their Massachusetts representatives, being of more uneven texture and containing a larger proportion of hornblende. The hornblende, which is frequently much decomposed, is of a deep brown color in thin sections and strongly dichroic. It contains numerous inclusions, such as apatite, magnetite, and zircon, although these last are not as prevalent as in the Gloucester rock; some biotite is also present. The feldspar, as in the Massachusetts rock, is nearly all orthoclase, is quite impure and opaque, and the quartz contains many inclusions and cavities, some of which are quite large. Although of the same mineral constitution as the Cape Ann granites, these are of decidedly inferior quality, being softer and less tenacious. It is more than probable, however, that when the quarries have been worked to a sufficient depth a far better quality of rock will be produced.

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a It is very probable that much of the black mica of our granites is not biotite, but lepidomelane or annite, these being the names given by Professors Dana and Cooke to the black mica of the Cape Ann granite. Such differ from biotite in containing sesquioxide of iron in place of the protoxide, and in being more opaque and less elastic. Their optical properties are, however, identical with biotite, and in the present work no such distinction has been deemed advisable. All black dichroic micas have, therefore, been called biotite. (See *Hawes' Min. and Lith. of N. H.*, p. 82.)

A coarse, red hornblendic granite is quarried at Grindstone island, New York, in which, however, the hornblende has undergone extensive alteration, and which contains so large an amount of calcite as to effervesce distinctly when treated with a dilute acid. A little mica is present, which is of a copper-red color in the thin section, and a few small apatite crystals, together with numerous crystals of zircon. The rock contains considerable pyrite, which may be easily observed on a polished surface of the stone as small specks of a yellow metallic luster. The quartz occurs only in very small grains grouped together in the interspaces between the feldspars.

HORNBLENDE-BIOTITE GRANITE.

The rocks of this group stand intermediate between true hornblende and biotite granites, and combine to a certain extent the properties of both. The essential constituents are quartz, orthoclase, hornblende, and biotite, with the usual accessories. To this group belong some of our most beautiful granites. Plate V is from a magnified section of a granite of this class—the so-called black granite of Saint George, Maine, the black color being due to the abundance of hornblende and black mica. Under the microscope it is seen that the rock contains a small amount of quartz and a proportionately large amount of plagioclase, and that the hornblende predominates over the mica. The feldspars are very fresh in appearance, and the quartz contains but few cavities. Magnetite and pyrite are present, together with a little apatite. This rock also contains a very considerable amount of calcite, which must have an important bearing upon its weathering qualities. It is a very beautiful rock, acquiring a fine polish.

In this group must also be placed a part of the granite quarried at cape Ann, Massachusetts, although the two rocks in general appearance are totally unlike, the Cape Ann rock being coarsely granular and of a slight greenish tinge due to the orthoclase, which is the prevailing constituent. Quartz is abundant, and the black mica and hornblende are in about equal proportions. Under the microscope the feldspar is found to be moderately pure, and but little plagioclase is present, the feldspar, as is usual in rocks rich in quartz, being nearly all orthoclase. Numerous quite large microscopic zircon crystals are found intermingled with the hornblende and mica.

A third hornblende-biotite-bearing rock is quarried at Sauk Rapids, Minnesota. This is a dark gray granite, of which the general uniformity of structure is interrupted by frequent black blotches of about the size of a pea, which are caused by segregation of mica. The feldspar is of a slightly pinkish tinge, and by the microscope is seen to be very impure and murky. The quartz contains very many inclusions and cavities. The general quality of the rock is much inferior in point of beauty to those previously mentioned.

EPIDOTE GRANITE.

Although very many of our granites bear epidote in small proportions, usually visible only with the aid of a microscope, the cases in which it is of sufficient abundance to give a specific character to the rock are rare, the epidotic granite quarried at Dedham, Massachusetts, being at present almost the sole representative. This is a fine, even-grained rock of a light pink color, spotted with small specks of light green, which are due to the included epidote crystals. Under the microscope the epidote appears usually in irregular grains of a faint yellowish-green color, and is but faintly pleochroic. A little biotite is present, which has in nearly every instance become altered into a green chloritic product. The feldspar of this rock is quite impure and opaque. Owing to its fine, even texture the rock works easily and takes a good polish. The granite quarried at Lebanon, New Hampshire, contains epidote in considerable quantity, a thin section under the microscope showing innumerable small, nearly colorless, crystals scattered throughout the mass of the rock. They usually occur in groups or clusters, and are the cause of the light green blotches seen on a polished surface of the rock.

SYENITE.

If in a granite the quartz is absent, or becomes so small in amount as to become a merely accessory constituent, the rock is called syenite.

Syenite is quarried to a very small extent in the United States. In the system of classification there are just as many varieties of syenite as of granite which are characterized by the presence of the same accessory ingredients. Lithologically, many of these varieties are known to exist; mica syenites of the various kinds, hornblende syenites, augite or pyroxene syenites, and epidote syenites are all recognized; but none of the extensively-quarried building stones in the United States are syenites, although very beautiful rocks occur which would be much admired if they were introduced into the market.—G. W. H.[a]

GNEISS.

The gneisses or stratified granites are extensively quarried. Stratification is a circumstance very favorable to the extraction of stone for some purposes. For example, the perfection of cleavage in certain directions makes it easy to split large slabs from the mass, to be used for curbings, pavings, steps, etc. The stones can also be split in

[a] This paragraph is from Dr. Hawes' notes.

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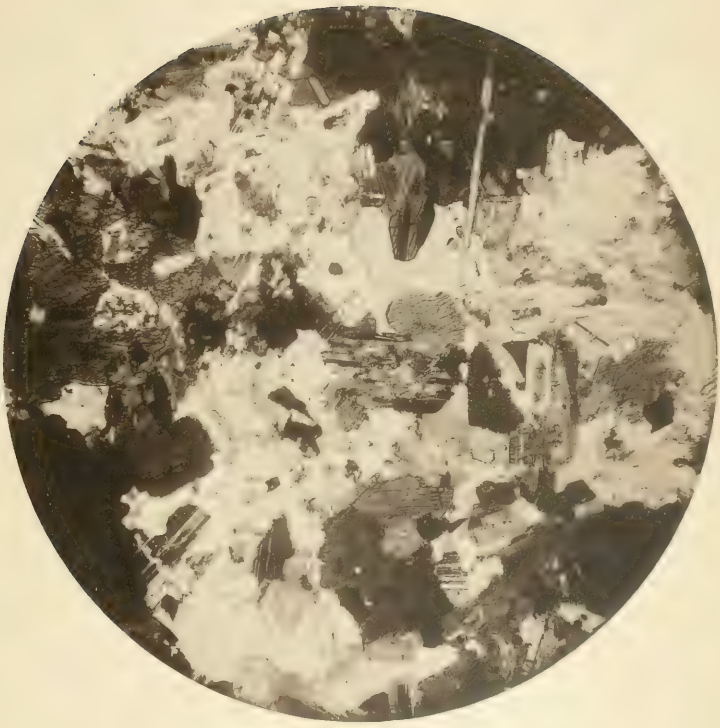

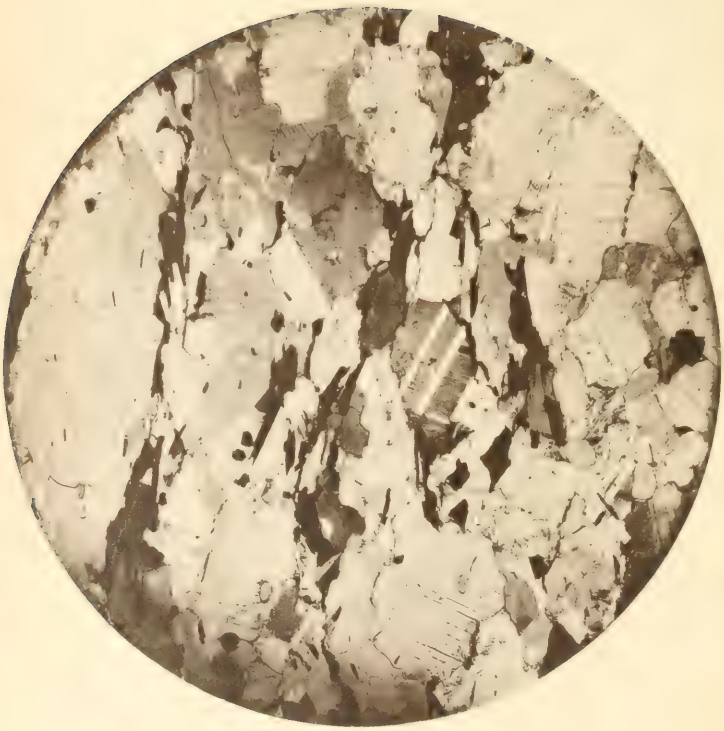

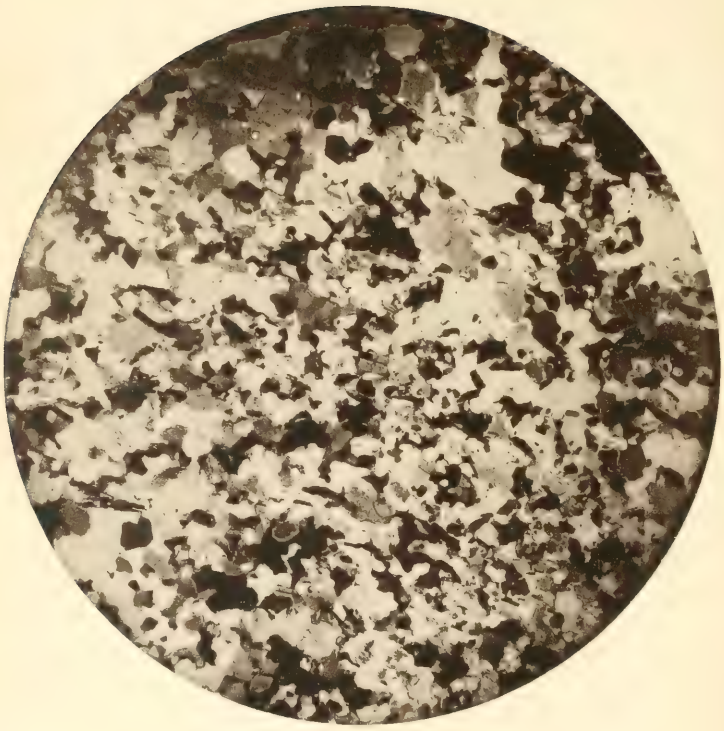

Mica Schist,

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such a way as to always possess two parallel flat surfaces, a circumstance which simplifies the construction of walls from them. The stratification is caused principally by the arrangement of the mica with its flat cleavage planes arranged in parallel directions.

Quartz and feldspar are again the essential constituents, and the same accessories constitute a series of gneisses identical with the granite series. We thus have biotite gneiss, muscovite gneiss, hornblende gneiss, pyroxene gneiss, etc.

There are no uses to which granite is applied to which the gneissoid rocks cannot also be applied; and some of the largest quarries in the United States which are called granite quarries really produce gneiss. In common nomenclature these rocks are called granite, or at best "bastard" granite or "stratified" granite, or granite with some other adjective prefixed. There is reason for this in the circumstance that they are used for the same purposes and very often have had the same origin, and differ from one another only in that some slight movement in the mass at the proper time gave a stratification to the rock. In certain cases also the stratification is very faintly evident, so that it is difficult to recognize as stratification. Indeed, there is no line of division between the granites and the gneisses when the structure alone is considered.

There are many gneissoid rocks which are very markedly stratified, which consist of alternate layers of very different compositions, and which were apparently deposited like the limestones and sandstones, and subsequently hardened and crystallized. Even in scientific classification it is now impossible to separate gneisses that have been deposited in stratified layers from those which have become stratified, as explained, by movements in a plastic mass. In this work there is no necessity for any distinction, and rocks of the composition of granite, but stratified in structure, will all be considered as gneisses, for, from the economic standpoint, structure is of more importance than questions as to the mode by which it was produced.

MICA-SCHIST.

Mica-schist is a rock that consists essentially of quartz and mica. It usually possesses a distinct schistose structure due to the parallel arrangement of the quartz and mica, as was noted in the gneisses, from which it may be said to differ only in its lack of feldspar. It is a rock which is supposed to have been formed by the deposition and subsequent crystallization of sediments, and consequently the structure of these minerals and their arrangement are markedly stratified. The peculiarities of the schists are not such as to render them favorites for purposes of fine construction. They are, however, broken out from the ledge with great comparative ease, and for rough construction, such as foundations and bridges, they are extensively employed.

The mica of the schists may be either biotite or muscovite, or both; in short, the schists may be characterized by one or more of the same accessories as are the granites and gneisses, and we may have just as many varieties. Through a diminution of the amount of mica these rocks pass into quartz-schists, and, by an increase of feldspar, into gneisses. The relative amounts of quartz and mica vary almost indefinitely. The percentage of silica, which is dependent largely upon the amount of quartz, varies from 40 to 80 per cent. The finer grained, more compact varieties of mica-schist make very fair building material, but the coarser varieties are not to be desired, especially if the mica be biotite and in great abundance.

In accessory minerals mica-schists are particularly rich. Some of the more common of these are garnet, feldspar, epidote, cyanite, hornblende, chlorite, staurolite, magnetite, pyrite, tourmaline, and rutile. Through an increase in the amount of hornblende or chlorite the rock frequently passes gradually into hornblende and chlorite schists.

As an illustration of the microscopic structure of a biotite schist, Plate VII is given. This is from a magnified section of the schist quarried in the vicinity of Washington, District of Columbia, and popularly called "Potomac blue-stone". As will be noticed, this rock consists almost wholly of quartz and biotite, the quartz being in irregular grains, while the mica occurs in ragged shreds. The prevailing schists throughout the vicinity are, however, by no means of so simple a structure.

As a general thing the District rocks are distinctly schistose, the mica laminæ being arranged in parallel layers, and the rock consequently splitting easily in the direction of its schistosity. In some cases, however, the various mineral ingredients are so evenly commingled that all traces of schistosity are lost in small specimens, and the rocks, especially if they contain hornblende, more closely resemble basic rocks of eruptive origin, for which they have at times been mistaken.

Under the microscope the mica is seen to be frequently of a greenish color and to bear numerous inclosures of apatite, magnetite, and garnet. More or less white mica is frequently present, though never in sufficient abundance to give any distinctive character to the rock. Hornblende, when present, is usually in the form of slender rhombic prisms, which are often broken transversely. It is of a yellow or greenish blue color, polarizing in deeper blue, or the lighter varieties in lively yellow and red, closely resembling augite. The crystals are quite imperfect, and are in many cases filled with inclosures of apatite, magnetite, and mica. It is frequently observed to have undergone an alteration into a greenish chloritic product.

One of the more abundant accessories in these schists is apatite. This occurs in small, perfect crystals which are nearly colorless in thin sections, though polarizing in faint yellow and bluish colors. The crystals are usually quite small, seldom exceeding 0.5^mm^ in length. Small, nearly transparent epidote crystals are also sometimes present, and quite often a triclinic feldspar, which is apparently oligoclase.

Another accessory of by no means so common occurrence, though quite abundant in some of these schists, is rutile. This occurs in the form of minute four- and eight-sided prisms, seldom more than one or two millimeters in length, and of a deep brownish red color. Very small crystals are frequently found grouped together in nests of half a dozen or more, but the larger ones are always single and scattering. Geniculate forms, so characteristic of rutile, are met with but rarely. Their striking color renders them especially noticeable in spite of their small size.

Garnets are quite abundant, nearly every section showing one or more, and frequently they are so large as to be visible without the aid of the microscope. They are of rounded or irregular form, seldom with a perfect crystalline outline, and of a delicate salmon color, as seen in the section. They are sometimes quite pure, but many contain numerous inclosures of a black, opaque substance, which is probably magnetite, and also numerous quartz grains.

An accessory of more practical importance than any yet mentioned is the bisulphide of iron, or iron pyrites, which is only too abundant in much of this rock, occurring in cubical crystals and irregular grains of a brassy-yellow color and often of considerable size. On weathering, the pyrites oxidizes and disappears, but leaves its characteristic stain behind, and frequently produces the more serious result of disintegration.

DIABASE.

Under the term diabase is included a majority of the rocks commonly known as trap-rock and black granite. They consist essentially of augite and a triclinic feldspar, which is usually labradorite, though oligoclase and anorthite are not uncommon. As microscopic accessories they nearly always contain magnetite, titanic iron, and frequently apatite and black mica; hornblende and chlorite are not rare as products of alteration, a process to which these rocks, owing to their basic nature, are extremely liable. In texture the diabases are usually too fine to allow a determination of their mineral constituents with the naked eye, although porphyritic varieties are not rare. The color varies from dark gray to nearly black or greenish, according to the varying proportions of the different constituents.

These rocks are frequently called by the quarrymen and others black granite, although, as will be noticed, they differ from granite most decidedly, in containing no quartz, and in the feldspars being all triclinic; orthoclase, which is usually the predominating ingredient in the granites, being here entirely wanting. They are basic eruptive rocks of ante-Tertiary origin, and generally occur in well-defined dikes, cutting the surrounding formations in a manner very noticeable even to the most careless observer.

Plate VIII is from a magnified section of the diabase quarried at Weehawken, New Jersey. Identical (practically) with this are the trap-rocks quarried at various localities in New Jersey, Pennsylvania, and Virginia; and a similar rock, but of finer texture, comes from New Haven, Connecticut. The diabase quarried at Medford, Massachusetts, differs from those just mentioned in being of much coarser texture and in containing a pinkish feldspar and an abundance of black mica. An abundance of apatite is also present, and considerable chlorite. The feldspars in this rock are much decomposed, frequently so much so as to be almost unrecognizable. A micaceous diabase is also quarried under the name of black granite at Addison, Maine. This rock has a very complex structure. Besides mica, considerable hornblende is present, which results from the alteration of the augite, it being not infrequent to find a crystal the boundaries of which are unmistakably hornblende, while the center is still unaltered augite. A very similar rock, but containing olivine, is found at Indian River, Addison township, Maine. Olivine, however, is a mineral of very unstable composition, and is rarely found in an unchanged condition. In the present case almost the entire mineral has become changed to a serpentinous product, leaving but a small portion of the original substance near the center of the crystal still unaltered. Both of these diabases contain two varieties of plagioclase, and in addition to the minerals already named there are present chlorite, biotite, apatite, magnetite, and titanic iron, the last named being usually much decomposed and taking on very fantastic forms. A section of this rock is given on Plate IX.

An olivine-bearing diabase is also quarried at Vinal Haven, Maine, though in this case the olivine is much less altered than in the Addison rock. A little chlorite is present, and some biotite, but the composition of the rock is much less complex than is that of the stone from Addison.

BASALT.

True basalt is but little used for building purposes. Like diabase, it consists essentially of a triclinic feldspar, augite, and titanic iron or magnetite, or both. Olivine is also almost invariably present, while nepheline, leucite, hauyne, apatite, and mica are common accessories. It differs, however, from diabase in being usually of finer texture, and of more recent origin.

Of the same composition as diabase we would naturally expect to find the included minerals undergoing the same processes of alteration, which is often the case. Calcite, zeolites, chalcedony, and carbonate of iron often

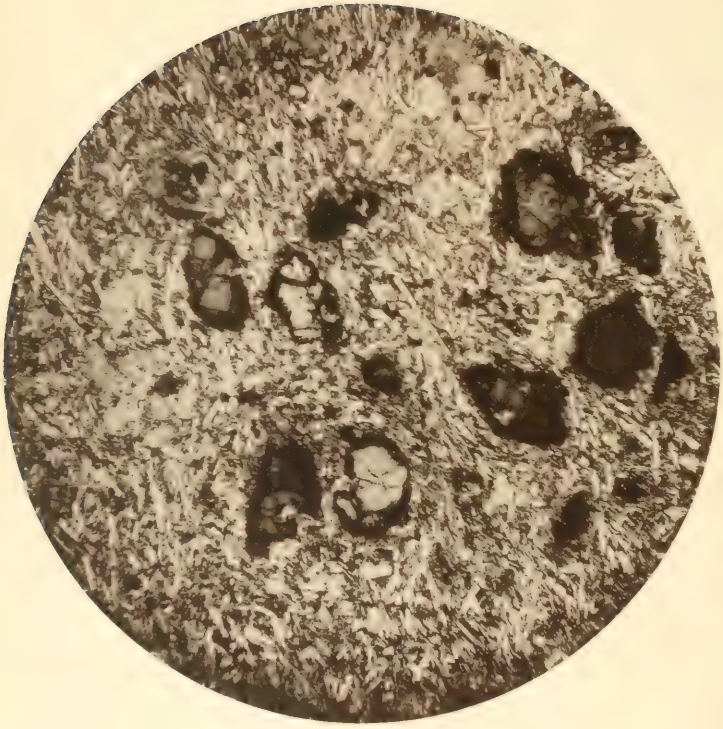
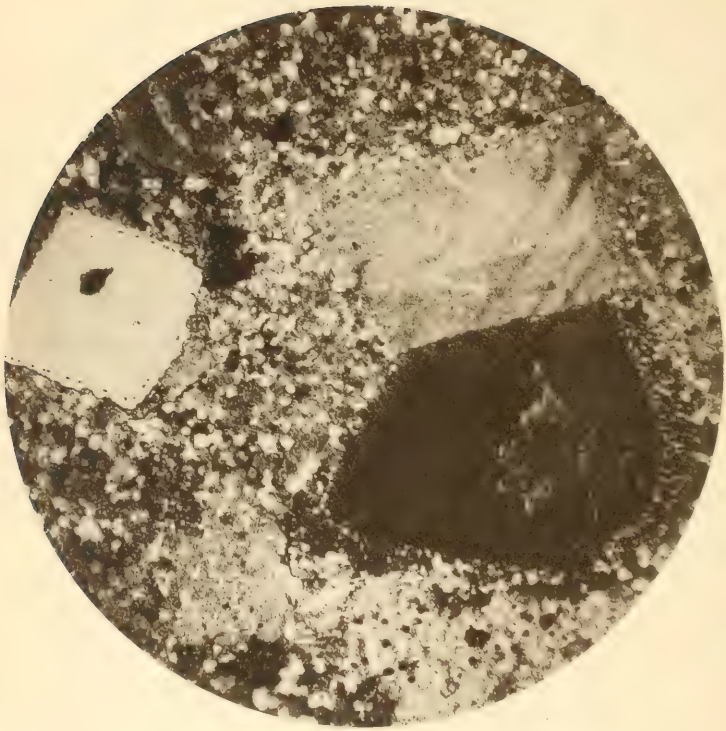


PLATE X.

Welz Photography

Penfield, Pa



occur as secondary products, lining the walls of the small cavities or amygdules with which the rock is frequently filled. The feldspar of basalt can be either oligoclase, andesite, anorthite, or labradorite, and it is usually the prevailing ingredient; the spaces between the individual crystals are frequently filled with an unerystalline, glassy magma, containing often numerous opaque, elongated, hair-like bodies, called "trichites".

Microscopic sections of basalt present many interesting features. The plagioclase usually occurs in small, slender crystals, showing in polarized light the customary banded structure, due to twinning. It is usually quite pure and free from all inclusions or cavities. The olivine appears rarely in well-defined crystals, but rather in rounded grains, traversed by many irregular curvilinear lines. They are sometimes of considerable size, so as to be easily distinguished by the naked eye. The augite in basalts is generally rich in inclosures of glassy matter, and in rocks which have undergone considerable decomposition both the augite and olivine are often represented merely by pseudomorphs of a green matter, either serpentine or some other hydrous silicate. Plate X is from a basalt quarried at Bridgeport, California. This is a fine-grained, brownish-gray rock, in which the included olivine crystals appear as small, greenish, rounded grains, often the size of a pin's head, scattered throughout the fine gray ground mass, the separate ingredients of which cannot be detected by the unaided eye. In the plate they appear as large, rounded, dark grains, surrounded by the smaller crystals of augite and plagioclase, like islands around which the semi-fluid mass has flowed.

PORPHYRY (PORPHYRITIC FELSITE).

Under the term porphyry it is usual to include a class of fine-grained, compact, felsitic rocks, the composition of which is not determinable by the naked eye, owing to the minuteness of the constituent minerals. The rocks consist essentially of quartz and orthoclase feldspar, one or both of which substances is frequently, though not always, present in crystals of considerable size, which lie embedded in the close, compact ground mass.

Under the microscope these rocks, as represented by the building-stone collection, can be divided into two classes, (1) those in which the ground mass is easily resolved into a crystalline aggregate of quartz and feldspar grains, and (2) those in which the ground mass gives between crossed Nicol prisms the polarization colors of an aggregate, which, even by high powers, cannot be resolved into its constituent minerals, owing to their minuteness. In both classes larger crystals of either quartz or orthoclase may or may not be developed to give rise to the well-known structure called porphyritic. According to which of these minerals is thus developed we have two kinds of porphyry—quartz porphyry and orthoclase porphyry. These two varieties are shown on Plates XI and XII. Plate XI is a quartz porphyry from Fairfield, Pennsylvania. The large white body in the center of the field is quartz, while the surrounding material is an intimate mixture of the same mineral and feldspar, but in so finely divided a state as to be inseparable by even the highest powers. Plate XII is of an orthoclase porphyry from Stone mountain, Missouri. In this rock it will be noticed that the ground mass is distinctly granular, and the porphyritic structure is due to large crystals of orthoclase, in place of the quartz as in the preceding. Both rocks are much alike in general appearance, although differing so decidedly in microscopic structure.

Porphyries are usually of eruptive origin, occurring in dikes, after the manner of what are popularly called trap-rocks. The well-known porphyries in the vicinity of Boston are, however, according to some authorities, metamorphosed sedimentary deposits. (*a*)

Porphyries present considerable variation in color; whitish, flesh-colored, red, blue-black, black, and green are common varieties. They are very close-grained, compact rocks, and take an excellent polish. They are also almost indestructible, withstanding for ages the effects of weathering without appreciable change. Their hardness and lack of stratification, however, are great drawbacks to their extensive use, since they can be taken from the quarries only in small, very irregular blocks, and are cut with extreme difficulty. They are at present but little used for building purposes in this country. In Great Britain they are used chiefly for causeway stones and road metal, for which their hardness and toughness render them especially suitable.

SANDSTONES.

Sandstones are composed principally of rounded and angular grains of sand that have become cemented together through the aid of heat and pressure, forming a solid rock. The cementing material may be either silica, carbonate of lime, or an iron oxide. Upon the character of this cementing material is dependent to a considerable extent the color of the rock and its adaptability to architectural purposes. If silica alone is present the rock is light colored, and frequently so intensely hard that it can be worked only with great difficulty. Such stones are among the most durable of all rocks, but their light colors and poor working qualities are something of a drawback to their extensive use. The cutting of such stones often subjects the workmen to serious inconvenience on account of a sharp and very fine dust or powder made by the tools, and which is so light as to remain suspended for some time in the air. The hard Potsdam sandstones of New York state have been the subject of complaint on this score. Professor

a T. T. Bouvé, *Proc. of Boston Soc. of Nat. History*, 1862, p. 57; 1876, p. 217.

Geike, in writing on the decay of rocks, (a) mentions an instance in which a fine siliceous sandstone, erected as a tombstone in an English church yard in 1662, and afterward defaced by order of the government, had retained the marks of the defacing chisel upon its polished surface perfectly distinct after a lapse of over two hundred years.

On the other hand, those rocks in which carbonate of lime is the cementing material, although soft enough to work well, are frequently too soft and crumble easily, beside disintegrating rapidly when exposed to the weather. On many accounts the rocks containing the ferruginous cement are preferable, since they are neither too hard to work readily nor are they liable to so unfavorable alteration when exposed to atmospheric agencies. These rocks also have a brown or reddish color, which is usually considered as something in their favor. The celebrated Portland brownstone, used so extensively for building purposes in New York city, is a good representative of this variety.

Sandstones are of a great variety of colors; light gray (almost white), gray, buff, drab or blue, light brown, brown, and red are common varieties, and, as already stated, the color is largely due to the iron contained by them. According to Mr. G. Man (*b*) the red and brownish-red colors are due to the presence of iron in the anhydrous sesquioxide state; the yellow color to iron in the hydrous sesquioxide state, and the blue and gray tints to the carbonate or the protoxide of iron. It is also stated that the blue color is caused sometimes by finely-disseminated iron pyrites, and rarely by an iron phosphate. (*c*)

In texture sandstones vary widely, from an almost impalpable fine grained stone to one in which the individual grains are the size of a pea. The coarser varieties, in which the grains sometimes reach an inch or more in diameter, are called conglomerates, or if the pebbles are angular instead of rounded, a breccia.

Sandstones are not always composed wholly of quartz grains, but frequently contain a variety of minerals. The brown sandstones from Connecticut, New Jersey, and Pennsylvania are found on microscopic and chemical examination to contain one or more kinds of feldspar and frequently mica, (*d*) having in fact the same composition as granite or gneiss, from which they were doubtless originally derived. According to Dr. P. Schweitzer, (*e*) a fine-grained sandstone from the so-called palisade range in New Jersey contains from 30 to 60 per cent. of the feldspar albite. That quarried at Newark contains, according to his analyses, albite 50.46 per cent., quartz 45.49 per cent., soluble silica 0.21 per cent., bases soluble in hydrochloric acid 2.19 per cent., and water 1.14 per cent. This, however, must be regarded as an exceptional case, as very many sandstones contain no feldspar at all, being probably derived from a quartzose rather than from a granitic rock. Some sandstones are thought to originate from chemical deposition, rather than from the disintegration of pre-existing rocks. Certain of the crystalline sandstones of Ohio are of this class. (*f*)

The minute cavities and moving bubbles so frequently seen in the quartz grains of granite are, as would naturally be expected, also occasionally found in sandstone, as is well shown in a white Potsdam sandstone quarried at Fort Ann, in the state of New York. The cavities in this case are extremely small, but the imprisoned bubble, as it glides unceasingly from side to side of its minute chamber, is readily seen with a microscope of high magnifying power.

Iron pyrites is a common ingredient of many sandstones, occurring frequently in cubical crystals or irregular grains of considerable size, and of a brassy-yellow color. Unless quite abundant, however, the chief danger to be apprehended from the use of such stone is the change of color it undergoes through the oxidation of the pyrites, which causes rust-colored or dark stains to appear wherever it exists. The beauty of many fine buildings has been sadly marred through the discoloration of the stone used for cappings and cornices by the oxidation of the included pyrites. Stone for such purposes should be subjected to careful examination, and all pieces in which the pyrites occur promptly rejected.

Nearly all sandstones are more or less porous, and hence permeable to a certain extent by water and moisture. Manifestly, then, in localities subject to any extremes of temperature, only those stones in which this porosity is reduced to the minimum should be used for buildings, since disintegration must certainly result if, after the pores of a stone become filled with water, freezing ensues. It is on account of the destructive effects of freezing water that such porous limestones as those of Bermuda and of Florida are totally unfit for use in countries in which the temperature falls frequently below the freezing point, although very durable in warmer climates. All sandstones absorb water most readily in the direction of their lamination or grain. It therefore follows, as every stonemason knows, that stone to weather well should be laid with its bedding (lamination) horizontal, as it was first laid down by nature in the quarry; the stone will also offer the greatest amount of resistance to pressure if laid in this manner, and, it is said, will stand a greater amount of heat without disintegrating; an important fact in cities, where any building is liable to have its walls highly heated by neighboring burning structures. The porosity of some sandstones is characteristically shown by their manner of drying after a rain; some will dry very quickly, while others containing a larger amount of water in their pores will remain moist a long time. Ordinary sandstones will absorb from 3 to

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a *Geological Sketches At Home and Abroad*, p. 87.

b *Quarterly Journal of the Geological Soc.*, xxix, p. 360.

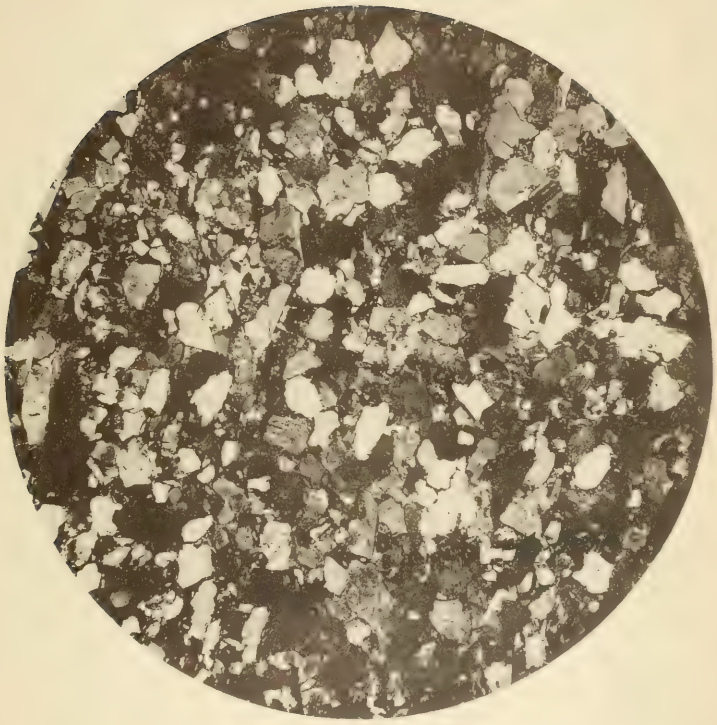
c *Notes on Building Construction*, Part III, South Kensington series, p. 55.

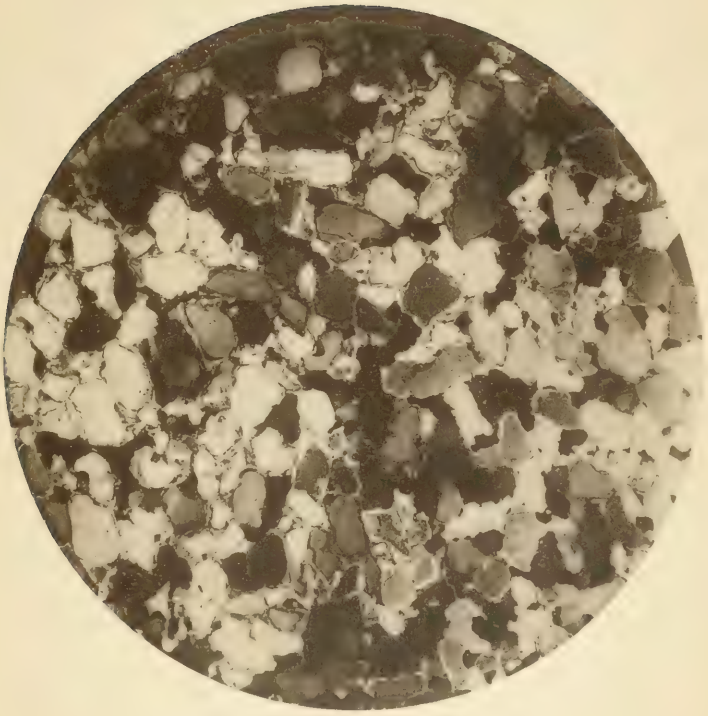
d See Plates XIII and XIV.

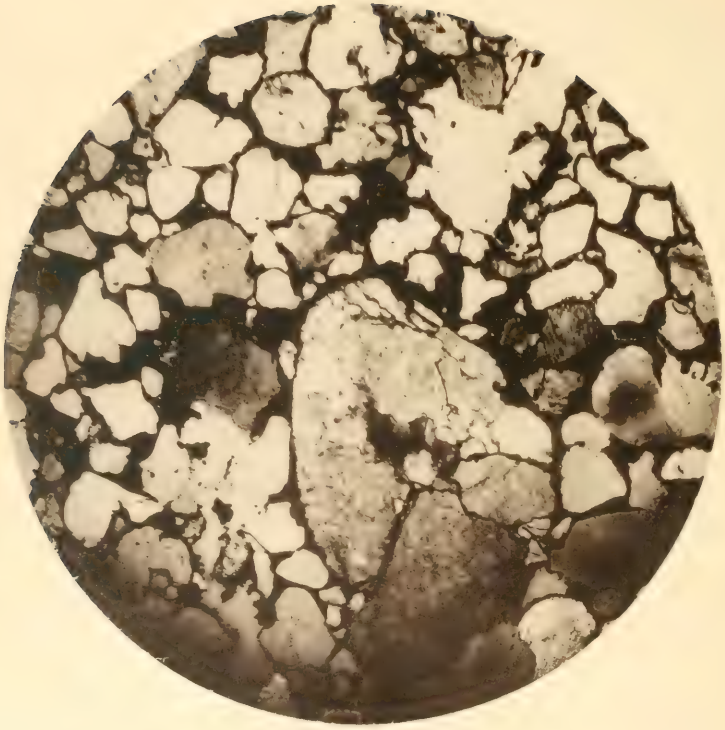
e *American Chemist*, July, 1874, p. 23.

f J. Brainard, *Proc. Am. Soc.*, 1880.

PLATE XI.







[illegible]

Estelville, N. J.

10 per cent., by weight, of water in 24 hours. Stone weighing less than 130 pounds per cubic foot and absorbing more than 5 per cent. of its weight of water in 24 hours, and effervescing somewhat actively with acid, is likely to be a second-class stone as regards durability. (*a*)

Some stones liable to the destructive effects of frost on first being taken from the quarries are no longer so after having been exposed for some time to the air, having lost their quarry water through evaporation. This difference is very manifest between stones quarried in summer and those quarried in winter. It frequently happens that stones of very good quality are entirely ruined by hard freezing immediately after being taken from the quarry (this being particularly the case with some marbles and limestones), while if they are quarried during the warm season of the year and have an opportunity to lose their quarry water by evaporation prior to cold weather they withstand freezing perfectly well. This phenomenon is easily accounted for if we admit the claim put forward by some that the quarry water of these stones carries in solution carbonate of lime and silica, which is deposited in the cavities of the rock as evaporation proceeds, thus furnishing additional cementing material and rendering the rock more compact. This will also account for the remarkable hardening of some stones after being quarried a short time, long since noted by those engaged upon stone work. When first quarried they are so soft as to be easily sawed and worked into any desirable shape, but after the evaporation of their quarry water they become hard and very durable. (*b*)

Conglomerate differs from sandstone only in point of structure, being coarser and of more uneven texture. This structure is well illustrated in Plate XV, which is from a magnified section of a conglomerate from Estelville, New Jersey. The large white grains are of silica and the dark cementing material is an iron oxide. These rocks are but little used for building purposes.

Quartzite is a hard, siliceous sandstone occurring in regions of metamorphic rock, and partially metamorphosed. It differs from ordinary sandstone in being harder and less friable. It sometimes possesses a well-defined schistose structure. Plate XVI is from a magnified section of a schistose quartzite from Berks county, Pennsylvania. Such rocks are very hard and compact, and would make very desirable building material.

LIMESTONES AND MARBLES.

Limestones consist essentially of carbonate of lime, though they are often more or less impure through the presence of organic matter and clay. It is usual to apply the name marble to those limestones that are highly crystalline in structure and susceptible of taking a good polish. The term is, however, very loosely applied, being sometimes made to include even siliceous crystalline rocks like granite. Limestones are mainly of organic origin; that is, they result from the deposition of organic remains, as shells, corals, etc. In many limestones these remains are still plainly evident, while in others they have become almost or entirely obliterated through metamorphism. The shell and coral limestones of Florida and of Bermuda are good examples of the first kind. In these the broken and water-worn fragments are simply cemented together by the same material in a more finely divided state without a trace of crystalline structure; and from these to a perfectly crystalline marble, without a trace of fossil remains, there is a constant gradation. The red mottled and black marbles of Tennessee and of Isle La Motte, Vermont, are good examples of the semi-crystalline varieties. In these the microscope shows very plainly the remains of minute organisms, while at the same time the surrounding portions of the rock are crystalline. The oolitic limestones used so extensively for building purposes in Kentucky, Indiana, and Iowa are composed of the rounded grains of shells and corals closely cemented, and forming a very durable stone. They are generally quite soft and easily worked when first quarried, but become harder by exposure. The size of the individual grains is usually about that of a fish-egg, though they sometimes are larger, reaching the size of a small pea, when the stone is called pisolite. Some limestones are scarcely at all crystalline, nor do they show any trace of organic remains, but are perfectly homogeneous throughout. The stones quarried at Huntingdon, Pennsylvania, and at Kokomo, Illinois, are good examples of this variety. These stones are sometimes quite easy to work, though, being dull in color and not capable of receiving a good polish, they are not very desirable. They are usually very impure through the presence of clay and earthy matter.

Of the perfectly crystalline limestones, the white and the blue marbles quarried so extensively at Sutherland Falls and Rutland, Vermont, are the best examples. These are supposed to have been originally common fossiliferous limestones, and to have become crystalline and had all their fossils obliterated through the aid of heat and pressure. In some of these marbles the process of metamorphism was incomplete, and the traces of fossils still remain. According to some authorities (*c*) many limestones result not from fossil remains of animals, but from chemical precipitates from sea-water.

a *Notes on Building Construction*, South Kensington series, Part III, p. 36.

b See Chateau, Vol. I, p. 265.

c T. S. Hunt, *Chemical and Geological Essays*, pp. 82 and 311.

The white crystalline marbles vary greatly in texture, the finest being found in Vermont, and coarser varieties farther south and west. According to Dana (*a*) the texture is less coarsely crystalline in Vermont than in Massachusetts, the crystallization of the limestone as well as of associated schists increasing in coarseness from north to south, or rather southwest, which is the trend of the limestone belt. The whitest marble of Rutland is not as firm as that mottled with gray, owing apparently to the fact that it was made white by the heat that crystallized it burning out any carbonaceous matter, while at Pittsford, 16 miles to the north of Rutland, it is very firm, and is white, probably because it was made with less heat from a whiter limestone.

Statuary marble is a pure white crystalline marble of very even texture; it is sometimes called saccharoidal, from the resemblance of its grain to that of pure loaf-sugar. Ophiolite or verd-antique is a mixture of limestone and serpentine, as will be noticed further on.

Carbonate of magnesia is a common ingredient of many limestones in varying proportions, and such stones are called magnesian limestones. When, however, the substances are present in the proportion of 54.35 parts of calcium carbonate to 45.65 parts of carbonate of magnesia, the stone is no longer called a limestone, but a dolomite. These stones are highly valued for building purposes, and "the best varieties are those in which there is at least 40 per cent. of carbonate of magnesia with 4 or 5 per cent. of silica". The nearer a magnesian limestone approaches a dolomite in constitution, the more durable it is likely to be.

It is not merely the nature of the constituents or their mechanical mixture that gives dolomite its good qualities; there is some peculiarity in the crystallization which is all important.

In the formation of dolomites, some peculiar combination takes place between the molecules of each substance; they possess some inherent power by which the invisible or minutest particles intermix or unite with each other so intimately as to be inseparable by mechanical means. On examining with a highly magnifying power a specimen of genuine magnesian limestone * * * it will be found not composed of two sorts of crystals, some formed of carbonate of lime and others of carbonate of magnesia, but the entire mass of stone is made up of rhomboids, each of which contains both the earths homogeneously crystallized together. When this is the case, we know by practical observation that the stone is extremely durable. (*b*)

The impurities in limestones are numerous. Many contain sand, which greatly injures their weathering properties; others contain clay and earthy matter, which are also elements of weakness, since they possess no strength in themselves, and, in addition, absorb water with the greatest ease, which renders the stone more liable to disintegration by freezing. Iron pyrites is a common impurity of many limestones, and such are to be avoided. Many of the Pennsylvania marbles contain talc or mica. A beautiful, coarse, rose-red marble from Danville, New Jersey, contains an abundance of black mica, which occurs in small hexagonal crystals. A limestone in the vicinity of Chicago, Illinois, contains petroleum to such an extent that blocks of it which have been used for building, become discolored by its exudation after a short exposure to the air, and this becoming mixed with the dust of the air forms a very unsightly tarry coating on the surface of the stone. "This rock, though porous and discolored by petroleum, is, when freed from this substance, a nearly white, granular, crystalline, and very pure dolomite, yielding 54.6 per cent. of carbonate of lime." (*c*) This oil is not always noticeable at first, but its presence can easily be detected by the well-known odor of petroleum which a sample of the rock gives off when struck with a hammer.

Oxide of iron is a common ingredient of many limestones, and to this substance is due the red color of the Tennessee, Mallett's Bay, and other red marbles. The blue or black color so common in limestones and marbles is due to carbonaceous matter derived from the decomposition of plants and animals in the waters in which the stones were originally deposited. Its carbonaceous nature is made very evident when the stone is subject to a high temperature by its becoming pure white through the burning out of this substance.

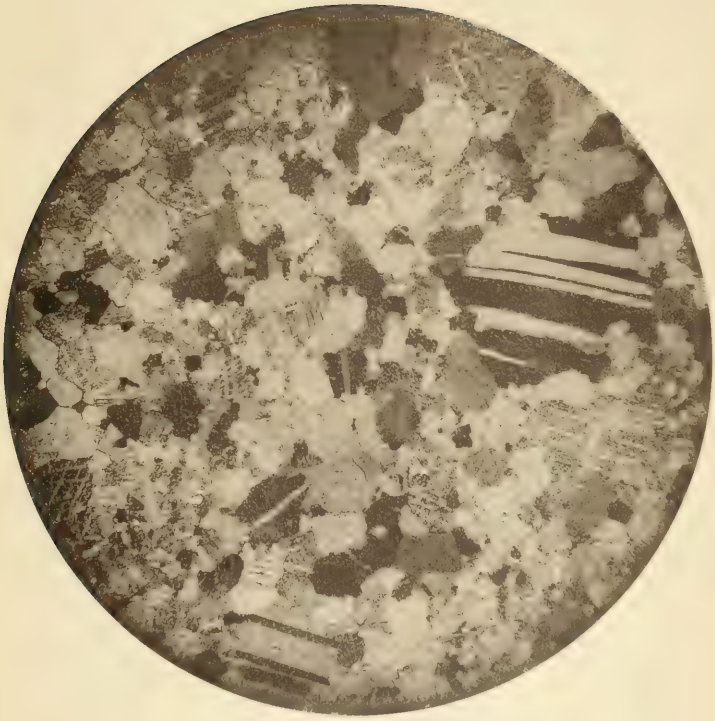
Limestones and marbles, owing to their beautiful colors and the ease with which they may be worked, are much esteemed for building and monumental work. They are not, however, the most durable of rocks, especially in cities where the air contains any considerable amount of carbonic, sulphuric, or chlorhydric acid, since these, even in very small amounts, readily attack the surface of the rock and cause it to crumble. A great deal naturally depends upon the texture of the stone. The most durable are those which are compact and homogeneous in structure and composition and not too coarsely crystalline. As a general thing the blue and gray colors denote a more durable rock than the pure white, for reasons already noted.

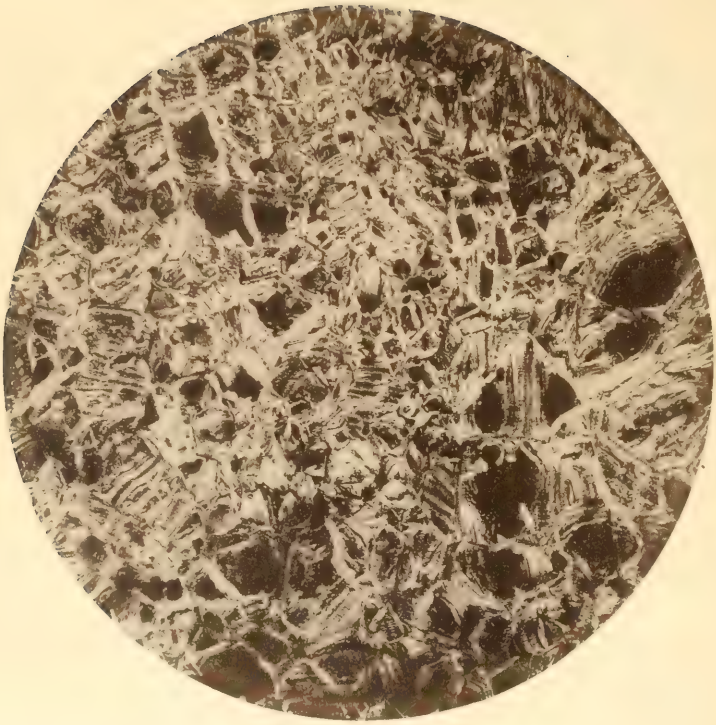
Limestones weigh from 112 to 185 pounds per cubic foot, the lighter weight being that of a shell limestone from Saint Augustine, Florida, and the heavier a compact, fossiliferous, semi-crystalline rock from Doughertyville, Tennessee. As would naturally be supposed, the heavier stone is much the more durable, being more compact and therefore less liable to injurious atmospheric influences. But few experiments have been made in this country upon the absorptive properties of stones, but according to the results of various experiments made in England, limestones vary in the amount of water they will absorb from 1 to 12 per cent., by weight, in 24 hours. The microscopic structure of a crystalline white marble from Rutland, Vermont, is shown on Plate XVII.

a *Manual of Mineralogy and Lithology*, p. 433.

b *Notes on Building Construction*, South Kensington series, Part III, p. 58.

c T. S. Hunt, *Chemical and Geological Essays*, p. 172.





SERPENTINE.

Serpentine is essentially a hydrous silicate of magnesia, consisting, when pure, of nearly equal proportions of silica and magnesia, with some 12 or 13 per cent. of water. The massive varieties used for architectural purposes are, however, always more or less impure, containing frequently from 10 to 12 per cent. of iron protoxide, together with small amounts of chrome iron, iron pyrites, clayey matter, and the carbonates of lime and magnesia. It is a tough, compact rock of quite variable color, usually greenish, though sometimes yellow, yellowish-green, brownish-green, or, more rarely, red, its colors depending, according to Delesse, (*a*) upon the degree of oxidation undergone by the included ferruginous material.

The origin of serpentinous rocks has been a matter of considerable dispute. Formerly they were supposed to be eruptive, but later investigations have tended to show that this is not the case, but that they result from the metamorphism of magnesian sediments, (*b*) or from the decomposition or alteration of gabbro, diorite, and other hornblendic rocks, or from rocks rich in olivine, as lherzolite. We have already noted the extent to which the olivine in the diabase of Indian River, Maine, had become altered into a serpentinous product, and it is hence easy to understand how large masses might be derived from the alteration of rocks in which olivine was the prevailing ingredient. Plate XVIII is from a magnified section of the impure serpentine from Chester county, Pennsylvania. It is a fine-grained, porous, dull green rock, and so soft as to be easily cut with a knife. In thin sections under the microscope it is of a faint yellowish-green color, showing in polarized light a somewhat fibrous structure, the fibers forming an irregular network, the interspaces of which are filled in many cases with calcite. Many black grains are present, which in some cases are magnetite and in others chromite: the chromite usually occurs in small black kernels, which are quite opaque, or at best but faintly translucent upon the thin edges, where they show a faint reddish color. It is strongly magnetic; the magnetite is distinguished from the chromite by its entire opacity and its metallic blue luster as seen by reflected light.

Serpentine is sufficiently soft to be easily carved into any desirable shape, and can be readily turned on a lathe. It acquires a good polish, and is one of our most beautiful stones for mantels, table-tops, and all manner of indoor work. For outdoor work the polished stone is entirely unsuited, since when exposed to atmospheric influences, especially in cities, it soon loses its gloss, and, the surface weathering unevenly, it soon becomes as unsightly as it was once beautiful. Verd-antique is a marble or limestone through which green or yellowish veins of serpentine are disseminated. According to Hunt (*c*) the verd-antique marble of Roxbury, Vermont, is a mixture of serpentine with talc and a ferriferous carbonate of magnesia.

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a Zirkel, *Petrography*, Vol. I, p. 320.

b T. S. Hunt on Ophiolites, *Am. Jour. Sci.*, Vol. XXIII, p. 239; also *Chemical and Geological Essays*, p. 317.

c *Silliman's Journal*, 2d, XXV, p. 226.

Chapter III.—CHEMICAL EXAMINATION.

By Fred. P. Dewey, *Smithsonian Institution.*

The optical method of study is not suited to solve all of the problems of lithology, and it becomes necessary to supplement it by chemical examinations. Even when the optical properties of a mineral have been thoroughly worked out, it can generally be determined with certainty only when sections of known relations to its crystalline form can be prepared. The sections of minerals ordinarily obtained in the preparation of microscopic sections of rocks are, however, hap hazard in their relations to the crystalline forms, and it is only by ascertaining these relations as far as possible, by an examination of outlines, cleavages, and other crystalline properties, that mineral species can be determined in rocks. The degree of accuracy which is thus obtained is sometimes insufficient for the desired purpose; for example, it can be determined that the feldspar in a rock is either the monoclinic orthoclase, the triclinic microline, or some one of the other species of triclinic feldspar, but which one of these it may be cannot with certainty be determined by optical examination. This is sometimes an important point. Again, in the case of minerals which can be determined with the greatest certainty, it is sometimes quite desirable to know the chemical composition of the species; for example, hornblende can, with almost entire certainty, be determined in thin sections of rocks, but this mineral is variable in its composition, and its properties as a constituent of a building stone may be quite different according as its composition varies, and especially according to the percentage of protoxide of iron it may contain. The composition of a rock as a whole, although important geologically, is of much less importance from an economic standpoint than the composition of individual ingredients, for the properties of the stone which fit or unfit it for use as a constructive material depend much more upon the peculiarities of its special ingredients than upon the ultimate composition of the whole. As is well known, a rock of a given ultimate composition may be a granite, a gneiss, a schist, a slate, or a sandstone, according to the circumstances of its origin and its subsequent transformation, and may be composed of very different mineral species; therefore, rocks of the same composition may be very different in their physical properties, and hence, in their capacities for resisting decomposing agencies and disintegration. It is therefore desirable to subject many of the stones which are to be considered as materials of construction to processes by which their individual mineral constituents can be separated from one another and analyzed. This indeed has been the object of those who are interested in the science of lithology, and various extremely complicated methods have been proposed to accomplish the result. A method has recently been proposed, however, which is much more efficacious than any previously applied, and as some of our results have been achieved by this method it will be briefly described:

The red iodide of mercury (HgI_2), possessing the high specific gravity of 6, is but slightly soluble in water; it is, however, very soluble in a solution of the iodide of potassium (KI), which has a specific gravity of 3.08. If, therefore, a saturated solution of the iodide of potassium is subsequently saturated with the iodide of mercury, a very heavy fluid is obtained, and the specific gravity of this fluid is such that many of the common minerals present in a rock will readily float upon it. This method of separation by means of a heavy fluid is said to have been proposed by Fleurian de Bellevue et Cordier at the beginning of this century. The solution of the double iodide of potassium and mercury was proposed by Church, in 1877, for use in the separation of minerals from one another. (*a*) The method was improved and new apparatus was proposed to be used with it by Thoulet, (*b*) who applied it with considerable success in the separation of minerals from granite and in determining the relative proportion of the various species in rocks of this nature. A further advance in the perfection of this solution was made by Goldschmidt, (*c* who succeeded, by a careful study of the most favorable proportions between the two salts, in increasing the specific gravity of the solution and in extending the utility of its application. He also fully studied its properties and demonstrated its great advantages as a separating fluid. According to Goldschmidt, the heaviest fluid is not obtained by saturating with iodide of mercury a previously-saturated solution of iodide of potassium, but by dissolving the two salts simultaneously in water, using a smaller proportion of iodide of potassium than that found by analyzing such a saturated solution. After some experimenting, the method of preparing this solution adopted by myself, and which gives a solution of the very high specific gravity of 3.28, is as follows: One part of iodide of potassium is weighed out and placed in a beaker, and one and one-fourth parts of iodide of mercury weighed out and placed on top of the iodide of potassium; then water is added in the proportion of 10 c.c. per 100 grams of the mixed salts; in the course of a few hours, with frequent stirrings, the salts will go completely into solution. After filtering from the impurities of the salts, the solution is gently evaporated on a water-bath

a Mineralogical Magazine, November, 1877.

b Bulletin de la Soc. Min. de France, 1879, No. 1.

c Inaugural—Dissertation, Philosophische Facultät der Universität Heidelberg, Victor Goldschmidt. Stuttgart, 1880.

until crystals just begin to separate upon the surface; it is then removed from the water-bath and allowed to become thoroughly cold, by which means a considerable crop of crystals separates and a fluid of between 3.10 and 3.20 is obtained. By pouring off the fluid from the crystals and again heating gently upon the water-bath until crystals begin to separate, a further portion of water is driven off from the solution, and upon cooling there is a further separation of crystals, and a fluid of the gravity of 3.28 is obtained. My experience in using this solution indicates that there is a double salt formed of the formula $(HgI_2)\ (KI)_2$ soluble in water, much more soluble, however, in water containing a small amount of iodide of potassium; but any increase of iodide of potassium beyond a certain small amount decreases its solubility, and consequently the specific gravity of the solutions obtained. This solution is a very remarkable one, and besides its use as a separating fluid it finds many other applications: especially is it used by the physicists on account of its high index of refraction.

For use in separating the mineral constituents of rocks it possesses peculiar advantages besides its high specific gravity, the most important being that it can be mixed with water without suffering any change in volume, thus allowing fluids of any desired specific gravity to be prepared; and also by a simple calculation the reduction of any known volume of fluid of any specific gravity to any desired specific gravity, the formula for this reduction being $V_1 = \frac{V(D-\Delta)}{\Delta - 1}$, in which V equals volume of fluid, D its specific gravity, V_1 the volume of water to be added, and Δ the specific gravity which it is desired the final fluid shall have. There are, however, some disadvantages connected with the use of the fluid, the most important being its poisonous and corrosive properties.

In order to separate the mineral constituents of a rock by the use of this fluid, the rock is first pulverized so that the particles will pass through a fine sieve, the size of the mesh being governed by the fineness or coarseness of the texture of the rock. It is desirable to reduce the rock to as fine a powder as possible to avoid the presence of composite grains; at the same time it is not practicable to reduce it to anything like the fineness of dust, as that would remain for a long time suspended in the fluid without either sinking or rising. The powder thus obtained is washed with water in order to separate from it the exceedingly fine portion which of necessity is formed during the pulverization; when the mass has been so long washed with water that the particles all settle very quickly to the bottom, it is dried and placed in a tube with two stop-cocks at the bottom, provided with a perforated india-rubber cork at the top, with a bent glass tube and an india-rubber tube for making connections, and also a capillary tube from between the two stop-cocks rising nearly to the top of the tube; the tube is also graduated to admit of the ready measurement and consequent calculations of the fluids during the separation; the double iodide solution is added, and the whole thoroughly mixed, preferably by drawing a current of air through the apparatus by means of the Bunsen pump; after remaining at rest for some time all those minerals present in the rock which have a higher specific gravity than that of the fluid fall to the bottom, and all that are lighter rise to the top; by opening the stop-cocks the portion which has settled to the bottom is drawn off; by closing the upper stop cock and drawing water into the lower portion of the tube by means of the capillary tube, the powder can be thoroughly washed from the apparatus; by adding water in successively calculated amounts to the fluid which remains in the tube, the other ingredients can be caused to fall to the bottom and be drawn off one by one—not, it is true, in a state of perfect purity, but in such a condition that the analysis of certain ones will very frequently lead to very important and desired results. The material which falls to the bottom when the fluid is at its highest specific gravity, generally complex in its nature, can be further analyzed by a variety of methods; a separation can very frequently be effected upon the ferruginous minerals by employing electro-magnets of successively increasing power. In some cases a separation can be effected by employing a mixture of chloride of lead of the specific gravity of 5 and chloride of zinc of specific gravity of 2.5, which fuses at a low temperature. A suitable mixture of the two chlorides can be fused in an elongated crucible and kept fluid at the lowest possible temperature; the heavy portion of the rock is then introduced and thoroughly incorporated with the liquid. After allowing a sufficient time for the rock materials to range themselves according to gravity, the heat is removed and the crucible is allowed to cool; by taking successive layers of the contents of the crucible and dissolving away the mixed chlorides a satisfactory separation can frequently be made.

The utility and the faults of the method will both be clearly recognized. As an example of its faults it may be mentioned that in the pulverization of the complex crystalline rock, no matter to what degree the pulverization be carried, some of the grains will of necessity be complex and float in the fluid in positions where they are not desired. The control, however, is kept upon the material intended for analysis by microscopic examination; and, although the full weight of the objection above mentioned is recognized, still results can be accomplished by the use of this solution which have been heretofore impossible.

There are cases of considerable importance in which the application of this method is especially satisfactory; for example, it is sometimes desired to separate from a rock one of its constituents which is either much heavier or much lighter than the other, and this can be done with the greatest ease. There are, on the other hand, cases in which the method is entirely inapplicable on account of the manifest impossibility of freeing the mineral constituents from one another, or of separating them from one another, on account of the presence of minerals with nearly identical specific gravities; and in general the perfection or the imperfection of the separations that may be effected

and the consequent value of the results can be determined by a consideration of the special cases as regards the minerals involved and the method of their combination, and by microscopic examinations of the sections and the separated products.

In the examination of the group of carbonates the chemical method has been almost exclusively used, and the classification is based upon this examination.

Of course the most satisfactory method would have been to make a quantitative analysis of each one, but with the large number to examine this was manifestly impossible, and a careful qualitative analysis giving an approximation to the relative amounts of the principal constituents was all that could be attempted. The method adopted was as follows: Measured portions of the powdered samples were introduced into test-tubes of the same size, and cold dilute hydrochloric acid was added, and the evolution of carbonic acid noted; the solutions were then boiled, allowed to settle, and the amount and character of the insoluble portion were carefully noted, and, when necessary, further examined. In a large majority of cases, however, the solutions were immediately precipitated by ammonia, and the amount and character of this precipitate noted; the solutions were then diluted with boiling water, measured portions of solution of oxalate of ammonia added to each, and the whole thoroughly shaken; they were then allowed to stand over night; the next morning the amount of precipitate of oxalate of lime was noted in each case; the solutions were then decanted into a second set of test-tubes, measured portions of phosphate of soda solution were added, and the whole rendered strongly alkaline by ammonia. After a thorough shaking they were allowed to stand twenty-four hours, when the amount of precipitate was noted.

In this way a tolerably fair idea of the approximate composition of the samples was obtained, and while there must necessarily be more or less variation in individual cases, it is thought as a whole the names adopted are just. In this connection it may be well to state that this work presupposes that the samples sent are truly representative samples as judged by the collectors, and that variations in separate quarries represented by specimens from one quarry, or even variations in the different parts of the same quarry, cannot justly be taken into consideration; and it must be borne in mind, too, that no classification of material so variable in composition as the carbonates can be rigidly exact. The system of names adopted is as follows:

Limestone, consisting of carbonate of lime.

Magnesian limestone, consisting of carbonate of lime with from 5 to 30 per cent. of carbonate of magnesia.

Calcareous dolomites, consisting of two portions, one of which is a true dolomite and the other effervescing freely in cold dilute hydrochloric acid.

Dolomite, consisting of carbonate of lime and magnesia, containing 30 per cent. or more of carbonate of magnesia.

Beside these, the following qualifying terms have been used:

Arenaceous, containing sand.

Argillaceous, containing clay.

Bituminous, containing carbonaceous matter.

Chapter IV.—QUARRY METHODS.

By F. W. Sperr.

For quarrying each different class of rocks there is a characteristic method employed, which is, however, varied in detail in nearly every different quarry. The minor details of quarry methods are as various as the differences existing in the textures, structures, and modes of occurrence of the rocks quarried.

The methods of draining the quarries and the methods of ordinary rock drilling are the same as those employed in mines.

Machines in great number and variety for quarrying and dressing stones have been invented, but reference is made in this report only to such machines as are actually in use.

THE USE OF EXPLOSIVES.

All building-stone deposits have usually a certain amount of covering, consisting either of a portion of the same deposit which has been disintegrated by atmospheric influences or of a later deposit. This covering is called the "cap-rock" or "stripping"; the solid portions of it are broken up by blasting, and the whole is carted out of the way.

After a sufficient space is stripped, the next step necessary, when the quarry rock does not stand out in cliffs or escarpments, is to excavate a narrow space on one side for a quarry face, either by blasting or by some of the methods of channeling described herein.

For the purposes of stripping the cap-rock and "forcing" the face, the result to be attained by the use of explosives is the breaking up of the rock so that it may be taken out of the way with as little expense as possible, regardless of the shapes into which the pieces are broken; for this no special skill is required in the manipulation of the blast. Much, however, depends upon how the blast is made for quarrying the stone which is to be used. In the first place, the directions in which a blast will break any kind of rock from the drill-hole are but two or three, and sometimes four, unless the explosive be too quick and forcible in its action. The limited number of directions in which the rock is most liable to break is determined by the structure of the rock and the shape of the drill-hole. Quick-acting explosives, like dynamite, have a tendency to shatter the stone and break it in many directions, the texture being affected by the sudden explosion in the same manner as by the blow of a hammer. Coarse gunpowder is generally preferred for quarrying stone; and this is seldom used further than for detaching large masses, which are subsequently worked up by means of wedges. The drill-holes are put down to the depth to which the rock is to be split, and the requisite amount of powder is put in, covered with sand, and fired by means of a fuse. Sometimes numerous charges in a line of drill-holes are fired simultaneously by means of electricity.

Light charges of powder lightly covered with sand are better than heavy charges tamped in tight; and experience goes to show that better work is done by repeated light blasts in the same hole than by one heavy blast. By means of light charges often repeated a mass of rock may be detached without breaking up, which would be badly shattered by a single charge strong enough to detach the block.

At Conshohocken, Pennsylvania, a peculiarly stratified limestone, containing some schistose seams or layers, is quarried by first detaching large masses by repeated charges of powder. The rift or stratification is nearly vertical. Holes are drilled for the blast, sometimes 20 feet or more in depth, as nearly as possible with the rift. After the rock is quite well opened (or "drawn") by the light charges, a charge of several kegs of powder is put in to throw out the mass, sometimes containing several thousand cubic feet. If a heavy charge is at first put in, the break, instead of taking the direction of the rift, is liable to go in three directions, as determined by the triangular shape of the bottom of the hole. It will always be observed that a hole when drilled with a steel-bitted percussion drill is never round at the bottom; and when the hand-drill is used the hole is always triangular at the bottom, and a blast in such a hole breaks the rock in three directions. The influence of the shape of the hole upon the effects of the blast was observed in the brownstone (sandstone) quarries of Portland, Connecticut, many years ago; and the following devices for controlling the blast have long been in use there:

Deep holes, from 10 to 12 inches in diameter, are drilled by machinery, and the charges of powder are made to have definite shapes by being put in canisters, which are placed in the drill-holes and tamped in with sand, so that the effects of the blast are the same as though the holes were drilled of the shape of the canisters. To make one break across in a straight line the charge is made to have a horizontal cross-section bounded by two minor segments of a circle, the canister being made of two pieces of sheet tin, with the edges unsoldered and the ends made of paper or cloth. The plane passing through the edges of the canister is that in which the rock is broken by the blast.

Two breaks may be made with a single blast in planes crossing at right angles to each other by using a canister which is a square prism.

The holes are drilled from 10 to 20 feet or more in depth. Sometimes two holes are drilled close together, so that the core between may be chipped out; and canisters 2 feet across from edge to edge are used with tremendous effect.

In many of the large quarries of sandstone in this country explosives are not used for quarrying the stone; but in nearly all the smaller quarries gunpowder is used. The influence of the shape of the drill-hole upon the effects of the blast does not seem to be generally known, and a great waste of material necessarily follows.

Granitic rocks are less liable to be injured by the use of explosives than the softer rocks; but even for quarrying granite powder is used no further than for detaching large blocks, except in rare instances. In every quarry of this class of stones there is found to be a certain direction in which the stone splits more easily than in others, even when the structure is most decidedly granitic, though quarries are often worked a long time before the cleavage plane is discovered. When the cleavage is not very marked it is called "the grain" by quarrymen; and when it is more decided, as in gneissoid and schistose rock, it is called the "rift". In rifted rock there is a secondary cleavage plane at right angles to the rift, and this is called "the grain". "Across the grain" is in a plane at right angles to the grain and rift, or to the two cleavage planes. When the rift is horizontal, or nearly so, it is said to be "with the lift".

In every different locality the structure of the rock must be carefully studied with a view to take advantage of the cleavage planes and natural joints in the management of the blast. There must be at least one free end to allow the block to move out toward the face; and the ends are often cut off by natural joints called "end joints". Horizontal joints, called "bottom joints", occur in most cases.

To detach a block a bore-hole is put down to the first bottom joint, and light charges of powder, usually of about four pounds each, are repeatedly put in and fired to "draw the break"; and after the rock is well opened a heavy charge of one or more kegs of powder is made to move out the mass. In this manner blocks from 15 to 20 feet in width and 100 feet or more in length may be detached. When the rift is vertical, as in the quarries at Monson, Massachusetts, a blast put in a simple bore-hole will break the rock with the rift, in one direction to the free end, and in the opposite direction to an end joint; or, if there be no end joint in that direction, the break turns out more or less abruptly across the rift to the face.

When the vertical bore-holes for the blast cross the rift the shape of the hole controls the directions of the break as in other classes of rock. A hole with an elliptical, horizontal cross-section will always insure a single straight break in a plane passing through the long diameter of this cross-section. These holes are made by drilling two holes as close to each other as practicable, and then chipping out the core with a chisel-bar. They are called "lewis-holes" from their resemblance in shape to the lewis-hole made in the top of the dressed blocks of stone to receive the clamp or lewis by which the blocks are lifted.

It sometimes happens that there are no bottom joints, except at great intervals. The method adopted for detaching the blocks in a case of this kind at the Penryn quarries, California, has been described to me by Mr. William Foster, who was employed as special agent of the Tenth Census to collect the building-stone statistics in the western states and territories. An undercut is blasted out along the first bottom joint and from one end joint to another; a lewis-hole or line of lewis-holes 20 feet in depth is put down from 15 to 20 feet from the face, and the blast breaks out the block between the end joints and down to the bottom joint, which is about 80 feet from the top. Blasts put into rock in this manner act more nearly like wedges than the ordinary blasts, and are capable of splitting off blocks containing 100,000 cubic feet of stone.

The trap-rock quarried so largely at Weehawken, New Jersey, for paving blocks is blasted out without regard to the shape or the size of the blocks obtained; the main object of the blast being to throw out and break up as much rock as possible. Heavy charges heavily tamped with sand are the most effectual for this kind of work. The detached blocks are drilled again and blasted with smaller charges till they are reduced to about the size of 2 by 3 feet by 1 foot, and these are broken into paving blocks by means of hammers. Sometimes a groove is "chased" across a block and a fire is built on the line of the groove to break open the block.

Such limestones as the massive oolitic limestones of Indiana and the soft limestones of Kansas are quarried by channeling and wedging; but most limestones are used for rubble, cellar walls, and ordinary dimension work, for which cheapness is the first prerequisite; and therefore the stones are quarried by blasting. Undoubtedly the cheapest method of quarrying small blocks is by the use of explosives, unless the rock is quite soft; and for this reason explosives are most generally used in the newest portions of the country for quarrying building stones. In the case of limestones the badly shattered portions of the rock are usually burned for lime. Thin-bedded limestones are often quarried by raising the sheets with iron or steel bars. In a new country, if there are loose bowlders upon the surface, these furnish the first building stones used, and are usually broken up with powder or with fire. Such was the condition of quarrying at Quincy, Massachusetts, one hundred and fifty or two hundred years ago, where are now some of the largest and most systematically worked quarries in the country. The method of breaking up bowlders by heating them with fire, and then striking them with heavy hammers or pouring water upon them, is perhaps the rudest and cheapest, and is certainly the most disastrous in its effect upon the quality of the stone.

THE QUARRYING OF STONE BY CHANNELING AND WEDGING.

By channeling is meant the process of cutting long narrow channels in rock to free the sides of large blocks of stone. The method of cutting the channel depends upon the nature of the rock. Marble was, until quite recently, channeled by hand, using a long steel bar, chisel-shaped at one end, cutting a channel about 1½ inches wide. This method is still in use to some extent, but it has been largely superseded by the use of machinery.

Quite a large number of machines for quarrying stone have been patented in this country, but only the Wardwell channeling-machine and the Sullivan diamond channeling-machine have as yet proved successful. Each of these machines has its special merits for certain kinds of work, and both of them are often used in the same quarry for different portions of the work. In marble, these machines taken together are capable of doing all kinds of channeling required.

The machine illustrated in the cut, Plate VII, is a double-gang Wardwell channeler, it being the one mostly in use and adopted for all kinds of stone, except grit sandstone, and is represented mounted upon a steel-rail track on the bed of a quarry. The frame which supports the boiler, engine, and other machinery consists of one piece of forged iron weighing nearly a ton, thus furnishing great durability. The engine is of six horse-power, its shaft carrying a balance-wheel on each end, to which is attached an adjustable wrist-pin plate. The levers which operate the gangs of cutters are pivoted at their rear ends to an extension of the frame. The free end of the upper lever passes through a sliding stirrup or swivel attached to the wrist-pin plate (not shown), giving an up-and-down motion to that end of the lever as the balance-wheel revolves. The free end of the lower lever passes through a mortise in the back side of the lower clamp. Motion is communicated from the upper to the lower lever by means of clasps, between which the rubber springs are placed, as shown in the cut. The free end of the lower lever actuates the gang of cutters, which consists of five bars of steel sharpened at their lower ends and clamped together by head and foot clamps, the whole sliding freely on the standard. Of the five cutters, two have diagonal cutting edges and three have their edges transverse. The object of the diagonal cutting edges is to insure an even bottom to the channel. The center cutter extends the lowest, and they all together form a stepped arrangement each way from the center; thus when the machine is moving forward the center and two forward cutters operate upon the stone, and when moving in the opposite direction the other two with the center one perform the work. These bars of steel are from 7 to 14 feet in length, according to the depth of the channel to be cut. The upper ends of these bars are grooved to match corresponding grooves in the head clamp, for the purpose of preventing displacement of the cutters. The worm on the main shaft actuates the worm-gear upon the feed-shaft. The feed-shaft extends diagonally downward to the rear of the machine, where it terminates in a bevel pinion; upon the rear axle are placed two bevel gears, and, by means of the lever shown, either of these bevel gears may be thrown into action with the pinion. The motion thus communicated serves to turn the axle either forward or backward, according to which wheel engages the pinion. When the machine is required to be stationary the gears are so placed that neither engages the pinion. The short lever locks the gears in any of the required positions. The windlasses on each side of the machine are for raising the gangs of cutters out of the channels. The opposite side of the machine is exactly the same as the one already described. Channels are usually cut from 4 to 6 feet deep and 1½ inches wide, except that in sandstone they are cut 2 inches wide; and they can be cut within 3 inches of a vertical wall.

It requires three men to operate the double-gang machine; from 300 to 400 pounds of coal are used per day, and the cost of operating is from $6 to $9 per day. This machine is calculated to cut from 75 to 150 square feet of channel in marble and limestone, and from 150 to 200 square feet in sandstone, per day, doing the work of fifty men.

One form of the Sullivan diamond channeling-machine is illustrated on Plate VIII. The principle here involved is the communication of rotary and feed motions to drill-rods on spindles; and the special advantages held by the machine are that it is capable of cutting channels vertically or at any angle of inclination, and, with the machine detached from the boiler, that channels may be cut under an overhanging wall. At one end of the drill-rod is the drill-head, 1¾ inches in diameter, armed with carbon or black-diamond points, and supplied with small apertures or outlets for water, which is forced through the spindle and drill-head. The pump which supplies the boiler also supplies the drills, the feed to the different parts being regulated by stop-cocks. The jets of water wash out the borings and keep the drill-head from heating. The drill-rods are made of varying lengths adapted to make any required depth of channel to 9½ feet.

A continuous open channel is cut in the rock by two operations. By the first, a series of holes is drilled, distant from each other a little less than the diameter of the drill-head. The rock partitions thus left between the holes are drilled out by the second operation.

Holes are bored by the first operation, uniformity of distance between them being secured by a guide, and a short plain sleeve is used on the drill-rod just above the boring-head. For the second operation this sleeve is replaced by a double guide, whereby the action of the boring-head is confined to the rock partition between the holes previously bored.

In the above figure the machine is supposed to move back and forth so as to cut a separate channel with each spindle, while on Plate VIII the machine is so mounted as to move sidewise and cut a single channel with the two spindles.

For cutting vertical channels the Wardwell machine is considered the most economical, but for cutting oblique channels the Sullivan machine is used. When the excavation is carried with the inclination of the strata, as

illustrated on Plate II, the Sullivan machine is utilized to cut the oblique channel and portions of the vertical channels next to the overhanging wall. In such quarries the blocks do not come out rectangular in shape, and there is some waste of material, which becomes greater as the inclination of the strata becomes less. When the dip is not less than 50° the advantages of a horizontal quarry floor are sufficient to compensate for this loss of material; but when the dip is less than from 45° to 50° the channels are cut perpendicular to the plane of stratification with the Sullivan machine, and the blocks are quarried out rectangular in shape. A quarry with an inclined floor is illustrated on Plate IV.

After the requisite channel cuts are made about a block of stone it is necessary to undercut the block in order to release it. This is accomplished by drilling a series of holes about 8 inches apart along the bottom, and then splitting the block from its bed by means of wedges.

The work of drilling the holes is by quarrymen called "gadding". In most of the large marble quarries of this country this is accomplished by means of a machine, using the diamond spindle drill on the same principle as the Sullivan channeling-machine, and called a "gadding-machine". The holes are drilled to varying depths, depending upon the width of the block to be raised. In many quarries the blocks are made from 4 to 6 feet in width, and the bottom holes are gadded from 18 to 36 inches deep. The split is made with the common plug-and-feather wedges, which consist of two half-round pieces of iron (called feathers), tapering to a point at one end, and a wedge-shaped piece of steel called the plug. The length of the plugs is a little greater than the depth of the drill-holes in which they are to be used. The feathers are a little shorter than the plugs, and when two of them are placed with their flat sides together the large end just fits into the drill-hole, in which they are so placed that the points are left protruding slightly and the large end nearly reaching the bottom of the hole. The plugs are inserted between the points of the feathers, and when they are all thus set they are driven simultaneously till the block splits from its bed. A few of the wedges are then overdriven to loosen the others, in order that they may be withdrawn and used elsewhere.

In the Cockeysville marble quarries, near Baltimore, Maryland, the blocks are channeled from 8 to 15 feet in width by using one side of the Wardwell machine and cutting single instead of double channels. To raise these blocks the bottom holes are drilled 2, 4, and 6 feet in depth, and a wooden plug about 2 inches in length is put into the bottom of each hole. The wedges or plugs are round bars of steel of a diameter a little less than that of the drill-holes, and their lengths exceed the depth of the holes in which they are to be used by about 3 inches. The portion of the bar which is wedge-shaped is about 8 inches in length, and to this the feathers, of about the same length, are tied, the large end projecting a little beyond the end of the wedge. The feathers and wedges thus tied together are placed in the holes against the wooden plugs, which allow the wedges to be driven through and beyond the feathers if necessary. A block 8 feet thick, 15 feet wide, and of any length may thus be raised. The gadding-machine is further used for gadding the holes for splitting the large blocks into sizes suitable for handling. This operation is illustrated on Plate II. When the machine is adjusted for work it is braced by driving the pointed legs near the trunk-wheels hard upon the quarry floor. The boring apparatus is attached by a swivel to a perpendicular guide-bar, which is secured to the boiler and forms the main support of the machine. The boring apparatus may be raised and lowered upon the guide-bar and turned upon the swivel so as to bore in any direction within the plane of the swivel-plate.

Steel-bitted machines have not yet been improved so as to cut or gad the holes along the bottom of the blocks sufficiently close to the floor, but for gadding the side holes such machines are used to good advantage. They are not capable of doing as much work as the diamond machines, but the high price of the carbon points places the latter machines at a disadvantage.

In Rutland marble an ordinary day's work for one man is to channel by hand 3 square feet; to gad by hand, in depth, 12 feet. An ordinary day's work for the Wardwell channeler is 50 square feet; an ordinary day's work for the diamond channeler is 60 square feet, for the gadder 180 feet, and for the steel-bitted machine (*a*) 100 feet.

The above figures do not indicate the capacities of the machines under wholly favorable circumstances, but only their usual work with the usual contingent delays.

Guides cannot be attached to percussion drills so as to confine the action of the tool to a narrow rock partition between the holes, as is done with the diamond drill; though in some granite quarries continuous open channels are cut with percussion drills by first drilling a series of holes, with a 2- or 2½-inch drill-bit, about three-quarters of an inch apart, which is as close as they can be cut without running into each other and wedging the tool. The cores are then chipped out by replacing the drill-bit by a tool of the same diameter, having a circular cutting rim and a diametrical cutting edge. The tendency to run off the core is partly obviated by the shape of the tool and partly by placing in the holes, on each side of the core, strips of hard wood of a thickness that will just allow the tool to go down between them. This seems to be the only practical method yet devised for channeling granite, though very little of this kind of work is done for the reason that the operation is very expensive on account of the hardness of the rock and because granite sustains less injury than the softer rocks by the use of explosives, which, therefore, may be employed for detaching large blocks without serious objection.

a The Ingersol rock drill is the steel-bitted machine used for gadding in the Rutland quarries. The Rand drill is used in some other marble quarries.

The work of breaking the large blocks of granite into smaller sizes is accomplished altogether by means of plug-and-feather wedges. To break the largest blocks of gneiss or gneissoid granite with the rift plug-holes from 4 to 6 inches deep and 8 inches apart are sufficient; but to break such blocks across the rift, or to split blocks having a truly granitic structure, about every third or fourth hole is drilled to a depth depending upon the thickness of the block and firmness of the texture, by which a more perfect fracture is insured. These deep holes are drilled with a striking-drill operated by three men, one holding and turning the tool and two men striking with heavy hammers or sledges. The other holes are drilled with small hand-drills. The feathers or half-rounds and plugs or wedges are smaller than those used in the softer kinds of stone. The 4-inch plug-holes, about three-quarters of an inch in diameter, and wedges and half-rounds 3 inches in length, are used for splitting blocks of considerable size. The wedges draw more perfectly if they are oiled before they are driven.

In most of the large sandstone quarries, except those in the hardest kind of sand-rock, channel cuts are made to some extent. Usually in the softer sandstones channels about 18 inches in width and from 4 to 6 feet and sometimes even 15 or 20 feet in depth are dug around the sides of the quarry with sharp steel picks, and the loosened material is thrown out with shovels. Other similar channels are often made, especially in large quarries, to cut off a certain portion of rock. Sometimes these channels are cut only on three sides of a quarry, to give a face and free ends. In the brownstone quarries of Portland, Connecticut, the channel necessary for a quarry face is made and the ends are broken off by blasting, as already described.

Having a face and free ends in a bedded, stratified, or unstratified sand-rock, a groove parallel to the face is cut across the top. The distance of this groove from the face may depend somewhat upon the thickness of the bed. A row of wedges is set in this groove and simultaneously driven till the rock breaks open. A long rectangular block is thus detached, and afterward cut into smaller sizes by means of wedges. For splitting small blocks, instead of the continuous groove a short groove is cut for each wedge.

When wedges alone are not sufficient to split off a block, holes are drilled at intervals and to depths as may be required, and plugs and feathers are used in connection with the wedges. When the rock is stratified, but not bedded, a row of wedges with or without plugs and feathers, as the case may require, is driven along the bottom to raise the block at the same time that the top row of wedges is driven. When the rock is neither bedded nor stratified it is best to channel off blocks of such width that they can be raised by wedging along the bottom.

The process of quarrying sandstone by the methods most commonly employed is illustrated on Plate V.

The Wardwell channeling-machine has recently come into considerable use for quarrying sandstone. The cutting-bars for this purpose are made to cut a channel 2 inches wide and 4 feet deep, and are sharpened at both ends so that they may be reversed when one end is dull. These cutting-bars need to be sharpened more frequently in sandstone than in marble.

The work of channeling with picks and shovels is very injurious to the health of the workmen on account of the sand-dust inhaled into the lungs.

In the North River blue-stone quarries the rock is bedded and so jointed that no artificial channels are necessary for freeing the sides of large blocks. A quarry face is secured by excavating the rock between two parallel joints, which may usually be found but a few feet apart. This is called "forcing", and is done by drilling holes and blasting out the rock with powder.

The blocks are raised by driving wedges into the bed joints, unless the beds are too thick, in which case a row of plug-holes for splitting the block is put in along a line of stratification. The lines of stratification are called "reeds", and mark the planes along which the stone can be split up into thin slabs; they usually occur at intervals of from 2 to 6 inches, though sometimes at greater intervals, when the stone cannot be split up into flagging, but is suitable for dimension work.

After the blocks are raised from their beds they are broken across by means of plug-holes, about 8 inches apart, drilled across the top. Small point-holes are also made between the plug-holes. The quarryman first drives the plugs tight and then drives the point into one point-hole after another all along the line, the object of this being to assist the wedges and to secure a straight fracture. The wedges and point are driven alternately till the stone breaks. Small blocks can usually be split along the planes of stratification by simply driving the point in along a reed.

Where the rock lies in thin beds or sheets the blocks are pried up with long steel bars. If slabs of less thickness than that of the natural beds are desired the blocks are split before they are broken across.

A peculiar method of reducing large blocks by means of wedges is employed in the limestone quarries at Conshohocken, Pennsylvania. This limestone is magnesian in composition, has a rifted or foliated structure, is capable of withstanding a great transverse strain, and works in a manner peculiar to itself. The large blocks are detached by blasting, as described on page 33, and are made to lie with the rift horizontal; lines of holes are drilled from the top as nearly through the blocks as possible without chipping out a piece at the bottom, and from one side horizontal rows of holes are gadded to a depth of from 1 foot to 3 feet, depending upon the size of the blocks. In this manner all the drill-holes necessary for reducing a large block with plug-and-feather wedges to blocks of required dimensions are drilled; the holes from the top crossing the rift (or "split") are drilled about 8 inches apart, and those from the side several feet apart. The blocks are first split with the rift and then across it.

In the soft-limestone quarries at Winfield, Kansas, a common auger, not pointed, is used for boring holes for the plug-and-feather wedges. A 1½-inch auger bores 6 inches in depth per minute.

In soap-stone quarries the blocks are at once cut up by the channels into sizes suitable for handling, wedges being used for cutting off the bottom only. A wedge fracture in soap-stone is somewhat ragged. The channel is cut to its full depth at one end, from which it is then cut back by paring off successive increments from top to bottom with a long steel bar having the cutting end beveled from one side. These bars are called chisel-bars or channeling-bars.

As all the softer rocks are more or less shattered when quarried by the use of explosives, the process of channeling has largely superseded that of blasting in this country for quarrying all kinds of rocks for building purposes, except slate and granitic rocks. It is the improved methods employed in quarrying that give the American marbles a claim to superiority over the Italian or Carrara marble.

At Carrara, Italy, the marble stands in immense cliffs on the sides of steep and rough mountains, and masses weighing many tons are blasted off and allowed to fall sometimes from 400 to 500 feet before striking. The jar sustained, both by the blast and by the fall, injures the texture of the stone, and causes, what is noticed everywhere in our cemeteries, the cracking of Italian marble after a few years' exposure. (*a*)

The worst feature attending the use of explosives for quarrying stone is that incipient cracks are produced, which do not open while the stone is being handled and dressed. Costly buildings are often marred and sometimes ruined by the cracking of some of the stones used in their construction. This disintegration is usually attributed to the non-resistance of the material to atmospheric influences, but it is more often due to the incipient cracks started in the quarry.

THE WORKING OF SLATE.

As slate is distinct in structure from all other rocks, so is the working of it essentially different. A few of the technical terms used by slate-workers it will be necessary to explain before proceeding with the discussion of the manner of working.

The SPLIT is the cleavage.

The GRAIN is a secondary cleavage at right angles to the split, and usually to a regular system of natural joints.

FLINT is a term applied to hard clay stones, quartz, or any hard rock which may be interstratified with the slate rock or occur in veins or concretions.

A QUARRY is where good slate rock exists developed or undeveloped.

STOCK is the useful rock taken out of a quarry.

The BUTT of a quarry is where the overlying rock comes in contact with an inclined stratum of slate rock.

The NOSE of a quarry is the line of contact between the underlying rock and an inclined stratum of slate rock.

END JOINTS are vertical joints running back from and perpendicular to the quarry face.

BACK JOINTS run parallel to the quarry face.

BOTTOM JOINTS are horizontal or nearly so.

The ENDS of a block are the surfaces which cross the split and are perpendicular to the grain.

The SIDES of a block are the surfaces which cross the split and are parallel with the grain.

To SCULP is to split a block with the grain by driving a chisel into a notch made in the end of the block.

To PLUG is to drill a hole near the middle of and through a block, and drive in a plug-and-feather wedge or put in a blast of powder to split the block with the grain.

To BREAK ACROSS is to break a block in a plane perpendicular to the grain and split by cutting a notch in one edge and then supporting the block at each end on this edge and striking with a heavy wooden mallet on the other edge and directly opposite the notch, or the block may be supported near the notch and struck near the ends on the opposite edge.

To SPLIT is to separate the slate along the cleavage planes.

In this country the slate is all taken out of open quarries, and the successive steps to be taken in quarrying slate are similar to those taken in quarrying other kinds of rock: The weathered material near the surface is removed; a quarry face is made by excavating a narrow channel down into the solid rock; large blocks are detached, and these are worked up into sizes suitable for handling, hoisted out of the quarry, and worked up by different processes for different uses.

The method of working a quarry depends chiefly upon the inclination of the cleavage plane and upon the direction of the grain; a quarry should always, however, be worked from the butt toward the nose.

In the Maine slate region the cleavage or split is nearly vertical and corresponds very nearly with the stratification. The grain in some of the quarries is vertical, and in others it is horizontal. The slate veins or strata occur alternately with flint veins, the former varying in thickness from 2 to 10 feet, the latter being less, but

a Mr. Edwin Grehle, a marble dealer of Philadelphia, says that when he visited the Carrara marble quarries the scene reminded him of the bombardment of a fort; that he has examined blocks of marble in some of the old ruins of Rome and found that the stone was somewhat worn but not cracked, but that scarcely a block of marble quarried since the introduction of gunpowder can be found free from cracks.

also variable in thickness. The quarries are worked from the butt, a slate vein is excavated for the face, and the flint vein on the upper side is allowed to stand for a wall. The face is excavated from 20 to 30 feet in depth and about the same in length before any stock is taken out. The flint vein on the lower side is then blasted out with powder and the next slate vein will usually be found cut up into blocks of greater or less size by end joints and bottom joints, and may be detached by driving in wedges at the top. Sometimes a hole is drilled in from the top so as to strike the next lower flint vein at a depth of 8 or 10 feet, light blasts are made to loosen the back joints, which in this case are joints along the cleavage, and the blocks are pried off with bars. Whenever no bottom joint is available at or near the floor of the quarry, an undercut must be made, and this is called blasting off the roots. When the grain is horizontal the excavation is carried down in steps, each from 20 to 40 feet or more in height. When the grain is vertical the step system is not uniformly adopted; but each underlying bed or vein is allowed to stand until a bottom joint is reached, which is seldom at any great depth; and, if the end joints are so far apart that the rock between them cannot be detached at once from the top, a space is blasted out at one end in the same manner as the roots are blasted off when the grain is horizontal; a hole is drilled half way between the top and bottom and from 10 to 20 feet from the free end, and a blast put in this hole splits the block from top to bottom. For splitting (or "plugging") off blocks in this manner the drill-hole must go through to a back joint; though such a joint may be made at any depth by putting a small charge of powder in the bottom of the hole and tamping it in tightly with sand, and the effect of the blast will be to cleave the rock along the cleavage plane passing through the bottom of the hole. If the hole is filled nearly full with powder and covered lightly with sand, the effect of the blast will be to make a clean break along the grain from top to bottom without shattering the rock; but if the powder is made to fill but half the hole and is heavily tamped, the effect of the blast is to break up and shatter the rock.

Experienced slate quarrymen show unusual sagacity by the manner in which they take advantage of the position of the rock as determined by the cleavage, grain, and natural joints, and by manipulating the blast so that it will produce just the effects desired. In the Vermont slate region the cleavage dips at an angle of about 45°, and, if the quarries are opened in the butt, one face cut will be sufficient for taking out all the rock which can be obtained without carrying the excavation under the overlying strata; but small quarries are often opened near the nose, where there is but a small amount of slate above the underlying strata, and when this is taken out a new face cut must be started from the top. There are a great number of small quarries opened in this region without regard to future workings and without any idea apparently of developing large operations. The débris is thrown on good slate rock, and the progress of large quarries has already in some instances been stopped by these piles of débris.

In the different Pennsylvania slate quarries may be found every different inclination of cleavage, direction of grain, and manner of jointing, but the general principles of quarrying are the same in all; that is, a face and free end are first made, after which large blocks are wedged off, pried off with levers, or plugged off with powder, and these blocks are plugged, split, and broken across till they are reduced to such sizes that they may be hoisted out of the quarry with derricks. If a block is small and less than one foot in thickness, it can be split by driving the sculp or paring-chisel into the edge of the block along a cleavage line; if the block is large, and it is necessary to use wedges for splitting, a series of wedge-shaped holes is cut along a cleavage line with the paring-chisel, two thin strips of iron are placed in each hole, and the wedges are placed between the strips of iron and driven.

Slate is used for a great variety of purposes, and if the blocks are to be worked up into roofing slate they are taken from the quarry to the splitters' shanties on small cars run on rail tracks between the quarry and the shanties. At each shanty are a splitter and two assistants. The first assistant takes the block upon its arrival and reduces it to pieces of about 2 inches in thickness and of a length and breadth a little greater than those of the slates to be made. The splitter cleaves these pieces into slates with the splitting-chisel. The second assistant trims the slates with irregular edges into rectangular shape and to definite sizes.

The process of sculping, which is carried out by the first assistant, is as follows: A notch is cut in one end of the block with the sculping chisel, and the edge of the notch is trimmed out with the gouge to a smooth groove extending across the end of the block and perpendicular to the upper and lower surfaces; the sculping chisel is set into this groove and driven with a mallet, and thereupon a cleft soon starts, which by skillful manipulation is guided directly across the block. The upper surface of the block is wet with water so that the crack may be more readily seen. If the block were perfectly uniform in shape and texture, and the blows upon the sculp directed straight with the grain, the crack would follow the grain in a straight line across the block. Almost invariably, however, the crack will deviate to the right or to the left, and must be brought back by directing the blow on the sculp in the direction in which it is desired to turn the break, or by striking with a heavy mallet against the right-hand side of the notch, if the break is to be turned in that direction, and *vice versa*. Some slate rock can be sculped across the grain, but most of it has to be broken across the grain.

The splitter uses a broad thin chisel for his work. He always splits the piece of slate through the middle, and continues to divide the pieces into equal halves until they are reduced to the required thinness. The edges of the blocks must be kept moist from the time the rock is taken from the quarry until it is split up, and when it is necessary to allow the blocks to lie a day or more some precautions must be taken to keep the edges moist. In some quarries the blocks split best from the side and in others from the end, and in some qualities of slate the splitting chisel may be driven in its whole length at once without danger of breaking the slate, while in others it is necessary to lead the split by driving the chisel slightly all around the edges of the block before driving it in at any one point.

There are many other little peculiarities which need to be watched by the splitter, and almost every different quarry presents some characteristic features which modify the working of the slate.

To trim slate by hand a straight-edged strip of iron or steel is fastened horizontally on one of the upper edges of a rectangular block about 18 inches in height; the trimmer lays the slate upon the block, allowing one of the irregular edges to project over the iron plate, and cutting it off by a chopping stroke with a heavy knife; in this manner he trims two edges at right angles to each other and then marks out the other two edges with a measuring stick before trimming them. The measuring stick has a nail through one end and notches or steps toward the other end at distances from the point of the nail corresponding with the lengths and breadths of slates made.

The machine for trimming slates consists of a horizontal steel plate, with a beveled edge upward, past which a heavy curved knife is made to pass by being revolved on an axle like that of an ordinary straw-cutter, or by being hung on a hinge and pulled up by a spring and down by a treadle operated by the trimmer. Projecting at right angles from the plate, a little upward and toward the operator, is an iron arm upon which there are steps at distances from the knife-edge corresponding with the lengths and breadths of slates made, and which thus serves as a guide for making the slates both rectangular and of definite sizes. The trimmed slates are set on end outside of the shanties, each different size in a row or pile by itself. Each square, which is the number of slates that will cover 100 square feet of roof, is set off in the piles by allowing one slate to project over the sides of the others.

For many purposes slate is worked up principally by machinery. The blocks are taken from the quarries to the slate-mills and there split into slabs about 2 inches in thickness and sawed into the required sizes with circular saws. If thinner slabs are required the sawed pieces are split. The sawed slabs are planed on one side or on both sides, as may be required, with a planing-machine like the machines used for planing iron. The planer-chisels vary in width from 2 to 6 inches, according to the softness of the slate. The planed slabs are laid on the rubbing-bed and rubbed with sand put on with water. The rubbing-bed is a flat, circular piece of cast-iron, from 8 to 10 feet in diameter, revolving horizontally on a shaft. The sand is put in a trough above the rubbing-bed. One end of the trough is a little lower than the other, and is near the shaft above the center of the bed, so that a small stream of water entering the upper end of the trough washes the sand slowly upon the bed and near its center. The sand gradually works to the outer edge of the bed, and is finally washed off as silt. The slabs of slates are prevented from being carried around with the bed by stationary arms or timbers extending across the bed, and within about one-quarter of an inch of its surface.

Slate does not receive a gloss polish, but if a finer surface is desired than that which can be given by the rubbing-bed it is rubbed by hand with fine sand or emery. Slates for billiard-table tops are jointed after being rubbed, the slabs being fastened to a table moving back and forth before a large revolving grindstone.

For mantels, table-tops, etc., and all kinds of marbleized work, the softer varieties of slate are preferred; they can be sawed with both circular and band saws, and are easily planed and rubbed. For tiling and other uses in which the slate is subjected to considerable wear the harder varieties are employed; the slate from the quarries at Chapmanville, Pennsylvania, is especially applicable for these purposes, and has to be sawed with diamond band-saws and diamond reciprocating saws. These saws are made by setting in teeth of black diamond or carbon points to do the cutting. In the quarries at Chapmanville steel drills are used, but at the mills all the drilling is done with diamond-set tools.

School slates are manufactured quite extensively at some of the quarries in the vicinity of Slatington, Pennsylvania. A large part of the work is done by machinery, and the improvements which have been made in this line are important. The slates are quarried and split the same as for roofing.

The following table shows the different steps taken in finishing the slates after they are split, and the number of persons required for one set of machinery capable of turning out about 20,000 slates per day:

Operations	Number of men.	Number of boys.	Number of women.
TRIMMING THE SLATES.			
Marking into rectangles and sawing with small circular saws	2		
Shaving the surfaces smooth with draw-knives	6		
FRAMING THE SLATES.			
Sawing boards into lengths for frame-pieces	1		
Sawing and grooving frame-pieces	1		
Tenoning and mortising frame-pieces	1		
Gluing tenons, mortises, and grooves, and sticking together an end and two side pieces		1	
Placing the frames on the slates		1	
Pressing the frames firmly on the slates with a machine-press		1	
Trimming the corners of the frames	2		
Planing the frames	1		
Printing rules on the inner edges of the frames			2
Punching holes in the frames			2
Sewing cloth upon the frames with shoe-strings			24
Packing and boxing the slates		1	
Total	14	4	28

The machine for printing the rules on the frames is a recent and valuable invention. The rules are divided into inches, half inches, and quarter inches.

These slates now supply almost the entire market of this country, and are quite extensively shipped to England, Germany, and other foreign countries.

THE GENERAL METHODS OF DRESSING THE VARIOUS CLASSES OF ROCKS.

1. The tools employed in dressing granite are the set, the spalling-hammer, the pean-hammer, the bush-hammer, the chisel, the bush-chisel, and the hand-hammer. The set is used for dressing the edges of a block to a line. The spalling-hammer is sometimes used for taking off larger projections than can be dressed off with the set; but such projections are commonly taken off with wedges (or "plugged off"). The point is used for roughing out the contour of surfaces. With the pean-hammer the projections left by the point are cut down. The bush-hammer imparts a finish according to the number of cuts employed. The chisel is used for finishing moldings, for cutting drafts around rock-faced and pointed work, and for lettering and tracing. The bush-chisel is used for dressing portions of surfaces not accessible with the bush-hammer. The set, point, and chisels are driven with the hand-hammer.

The steps in the process of dressing a granite surface are: 1st, dressing the edges to a line with the set; 2d, roughing out the surface with the point; 3d, cutting down the irregularities left by the point with the pean-hammer; and, 4th, dressing down, with the 4-cut, 6-cut, 8-cut, 10-cut, and 12-cut bush-hammers successively, the irregularities left by each preceding tool.

This process is carried out to different degrees for the different kinds of finished dressing known as rock-faced work, pointed work, single-cut or pean-hammer work, and 4-cut, 6-cut, 8-cut, 10-cut, and 12-cut work. For pointed work there is usually a draft chiseled around the face, after which the space within is dressed to a level with the draft or is given a certain projection, and may be rough-pointed or fine-pointed. Rock-faced work is sometimes drafted. The surfaces which come against other surfaces in masonry are dressed to a degree of fineness depending upon the closeness of joint required. Exposed surfaces are not often finished with the pean-hammer, the principal use of the single-cut being to prepare the surface for the next finer cut.

The condition of the surface at the completion of any particular cut work should be such that each cut in the hammer traces a line its full length on the stone at every blow. The single-cut should leave no unevenness exceeding one-eighth of an inch, and each finer cut reduces the amount of unevenness; and the 12-cut should leave no irregularities other than the indentations made by the impinging of the cuts in the hammer upon the surface of the stone. The lines of the cuts are made to be vertical on exposed vertical faces, and on the horizontal and unexposed faces they are made straight across in the direction which is most convenient.

For fine and accurate work all the tools designated in the complete process are used, except that a 5-cut hammer is often substituted for the 4-cut and the 6-cut hammers; but some of the tools are ordinarily omitted, the 6-cut being made to follow the pean-hammer, and the 10-cut to follow the 6-cut, etc.

A machine operating a bush-hammer by steam has been used, but not extensively. The hammer can be made to strike with any force up to a certain degree, but it cannot be guided with the delicate accuracy with which the bush-hammers are manipulated by hand. There are two other inventions for dressing granite by machinery not yet extensively tried. One of these inventions is the sawing of granite with gang-saws by the aid of chilled-iron globules.

Granite has been sawed with gang-saws by the aid of sand and with diamond-toothed saws; but the former process is too slow and the latter is too expensive to be profitable.

The essential feature of the other invention above referred to is a tool- or cutter-holder called the "chuck", which is furnished with three or more circular cutters set at an angle to the plane of their track or the path described by the edges of the cutters as they are carried round in a circle by the revolution of the chuck upon its axis.

Machines are made with the chucks and cutters variously adjusted for dressing plain and curved surfaces, the top and sides of blocks, different kinds of stone, and for turning columns.

The principal objections which have heretofore been urged against these machines are that the sand made by the dressing gets into the journals and between all the rubbing surfaces of the machinery, producing rapid wearing of these parts, and that the cutters are liable to chip out the edges of the blocks of stone. To overcome the latter objection an arrangement has recently been invented for producing more perfect arrises.

Granite is now used rock-faced in all cases where this mode of dressing is at all applicable. The use of granite for tombstones and ornamental work in general has greatly increased since the introduction of machinery for polishing. The cost of preparing a granite surface for polishing is, however, still great.

Before the introduction of machinery for polishing a polished granite surface was seldom seen; but now the polishing of granite is an extensive industry. The surfaces are prepared for polishing with the 10-cut or the 12-cut bush-hammer. The process of polishing consists in: 1st, rubbing with sand; 2d, with emery; and 3d, with putty-powder. All these polishing materials are put on with just sufficient water to make a paste which is not gummy. The process is commenced with rather coarse sand. The sand constantly works off and is caught on a shelf or in a pit, and for a time fresh sand is supplied; but as the surface becomes smoother the sand is taken from the shelf or pit

and put back upon the stone, the sand being ground finer and finer at the same time that a finer surface is produced. The impalpable powder or mud produced is carried off by the water. Emery is applied in the same manner as sand after as fine a finish as possible has been given by the latter. Putty-powder is rubbed on with a felt-covered block to give the surface a gloss finish. Flat surfaces are brought to a horizontal position, and the sand and emery are rubbed on with a horizontally-revolving iron wheel made of several concentric rings. The rubbing-wheels are usually from 12 to 18 inches in diameter: the machines are constructed on various plans, so that the wheels may be carried about over the whole surface to be polished, and so that the vertical shaft upon which the wheels are carried may be raised or lowered within certain limits by the operator to give different degrees of pressure. The felt-covered block for rubbing on the putty-powder is attached to the bottom of the wheel. Straight moldings are polished with blocks made to fit them, and worked back and forth by machines called "pendulum machines". Granite columns are polished in lathes.

2. The steps taken in the process of cutting marble are: 1st, shaping up the block with the spalling-hammer and pitching-tool; 2d, roughing out the surface with the point; 3d, cutting down the projection left by the point with the tooth-chisel; and 4th, cutting the surface smooth with the drove.

The spalling-hammer is used for breaking off the larger projections, and the pitching-tool is used for dressing the edges to a line. Chisels having a bit more than one inch in width are called "droves"; smaller sizes are called "tools".

A finished surface is usually drove, tooled, or polished. Rock-faced, pointed, and tooth-chiseled work are seldom employed. A tooled surface is made with the chisel, and has a ridged or wavy appearance due to the lines of indentations made by the tool. Surfaces are drove preparatory to polishing. The steps involved in the process of polishing are: 1st, rubbing with coarse sand; 2d, with finer sand; 3d, with coarse grit; 4th, with finer grit; 5th, with pumice-stone; 6th, polishing with Scotch hone; and 7th, glossing with putty-powder, with sometimes an addition of oxalic acid. Water is applied in every step of the process.

It is usually specified in contracts for polished work that no oxalic acid shall be used, because a more durable polish is obtained by the use of the putty-powder alone.

Small blocks are rubbed with sand on the rubbing-bed; otherwise, machines similar to those used for polishing granite are used for applying the sand and putty-powder. The grit consists of spalls from sand-rock which has a texture suitable for grindstones. The grit and pumice-stone and Scotch hone are applied by hand. Each step in this process must eradicate all traces of the preceding step; skillful workmen are required, and the work of imparting the gloss finish cannot proceed so long as there are any scratches whatever left in the surface.

A dressed surface of most colored marbles will have cavities, which must be filled before the marble is polished. This filling is done with a wax made of shellac and colored with any non-oily substance, which is applied with a red-hot strip of iron, and before the wax cools a little of the marble-dust is rubbed into it. The same material is also used for cementing pieces of colored marble together. There is yet no substance known with which white marbles can be filled; and, fortunately, the need of filling them is not often felt. White marbles are usually compact and colored marbles vesicular in structure.

Marble is quite extensively sawed with machines called "gang-saws", employing horizontally reciprocating saws which are aided by sand. The saws are plates of iron from 3 to 4 inches wide and one-eighth of an inch thick; their edges are smooth, and the actual cutting is done by the sand. As many saws are used at once on a block of stone as there are parallel cuts to be made. The saw-frames are supported by iron rods working on hinge-joints at both ends. Some machines are so constructed that the pressure on the saws is simply the weight of the saws and frame; but in other machines the frame is let down a certain amount at each stroke by screws worked by the machinery. By the latter arrangement the feed can be regulated to suit the texture of the stone.

The sand is placed on the top of the stone and fed into the kerfs with a water-drip. The sludge from the ends of the saws is caught in a pit, the silt is carried off by the water, and the sand is shoveled back upon the stone.

Iron plates, the cutting edges of which are segments of a circle, are revolved by a vertical shaft for sawing circular pieces out of marble slabs for sinks, wash-stands, etc. The saw prepares the surface for the process of polishing.

Various machines have been invented for doing different kinds of work in marble dressing, but only a few of them are found at all in use, excepting those referred to above.

In many localities in this country thinly-bedded limestones are the only stone material near at hand for purposes of construction. The beds of these stones are usually smooth enough to be used in ordinary masonry without dressing; the ends are jointed with the pitching-tool and point, and the faces are commonly dressed rock-face. Such stones are not used to any extent for superstructures, except for church edifices, their principal use being for building foundations, bridge piers and abutments, and other like structures.

Heavily-bedded limestones are commonly sawed with gang-saws, and the various kinds of finish given the faces are rock-face, pointed, tooled, drove, or rubbed. On some limestones the tooth-ax is used after the point, after that the ax-hammer, and then the diamond hammer.

For carving marble and other stones, as for carving wood, chisels, gouges, and drills, of various sizes, and special tools for special kinds of work, are used.

3. The steps in the process of cutting sandstone are similar to those in the process of cutting marble, except that the crandal takes the place of the tooth-chisel on large surfaces. The diamond-hammer is used after the crandal on some kinds of sandstone, and the bush-hammer is used on hard, compact, argillaceous sandstones like the North River blue-stone.

Blocks of sandstone are sawed with gang-saws, like blocks of marble. Some sandstones are so soft when first taken from the quarry that they can be sawed with gang-saws without the aid of sand. Diamond-toothed saws have been successfully used for sawing the Portland (Connecticut) brownstone. These saws, while they cut the harder varieties of sandstones more rapidly, are much more expensive than the ordinary gang-saws.

A rubbed surface is the finest finish of which sandstone is susceptible. The surfaces may be rubbed with sand alone, or with sand followed by grit.

Slabs of North River blue-stone are planed, like slabs of slate, before they are rubbed.

4. The greenstone, or serpentine, which has been used so largely for the construction of dwellings and other buildings in Philadelphia, and to some extent in other eastern cities, is dressed rock-face. The rock is considerably broken up in quarries by natural joints, and is still more broken up by the powder used in quarrying. A greenstone building standing among other buildings presents a pleasing appearance, but many greenstone buildings together present a less agreeable appearance; there is a harshness which has become more apparent with the increased use of the stone, and which has finally driven the stone almost entirely out of use. But the greenstone is certainly capable of producing beautiful architectural effects by contrast. Thus far the quarries have been worked in the outcrop only. Upon the further development of the quarries, and more systematic working, larger blocks applicable to a greater variety of purposes, and a material more susceptible of dressing, may be produced.

For carving stones, as for carving wood, chisels, gouges, and drills of various sizes, and special tools for special kinds of work, are used.

There can hardly be said to have been any advance made in the method of carving stone since the stone age, when the savage chipped one stone with another; but the sand-blast method bids fair to supersede the old method for some kinds of work.

The sand-blast has been most extensively used for engraving glass, but it has been to some extent used for carving stones. At a high velocity of impact, grains of sand will cut or wear away substances much harder than themselves. For engraving or carving, sand, grains of quartz, or any other hard material is rapidly driven against the surface to be cut by any propelling force; a rapid jet or current of steam, air, water, or other suitable gaseous or liquid medium is preferred.

A peculiarity of the sand-blast is that the grinding or cutting action may be made to take place upon irregular surfaces, cavities, corners, and recesses hardly accessible to ordinary methods.

The business of carving stones is yet in its infancy in this country, but it is rapidly increasing; buildings, both public and private, being more ornamented with carved stones as the wealth of the country increases.

DESCRIPTION OF PLATES ILLUSTRATING QUARRIES AND QUARRY METHODS.

PLATE XIX.—Portions of several more or less connected excavations, worked independently of each other. Posts or pillars are left to support the hanging wall or roof. On the floor, in the foreground, is a Wardwell channeling-machine for cutting the marble into long rectangular blocks. Whenever it is necessary to make the quarry deeper (to "go down in the floor"), one of the long blocks is cut into short, nearly cubical pieces, called "key-blocks". The first key-block may be broken off more or less near the bottom by driving wedges into one of the channels. After the first key-block is completely removed (the bottom may have to be dug out in fragments) a row of holes is drilled along the bottom of the second key-block, and wedges are driven into these holes to raise the block from its bed. In this manner each succeeding key-block is taken out. A long block is then raised by driving wedges into holes drilled along the bottom. The long blocks are split, along the lines of stratification, into pieces which can be handled by the hoisting machinery. The small, waste material is raised to the surface in cages, which are shown attached to the derricks.

PLATE XX.—Small portion of the second excavation of Plate XIX, as seen from the opposite direction. The inclined channels on the hanging-wall side are cut with the diamond channeling-machine. The machine in operation is a diamond gadding-machine, by which the necessary holes for splitting up a long block are being drilled. The quarried blocks are attached to the derrick ropes, as shown in the foreground, and hoisted to the surface.

PLATE XXI.—Portion of the second excavation of Plate XIX, at an earlier period, when the excavation was just being cut through under the pillar. The excavations are usually carried down by steps, as shown on this plate.

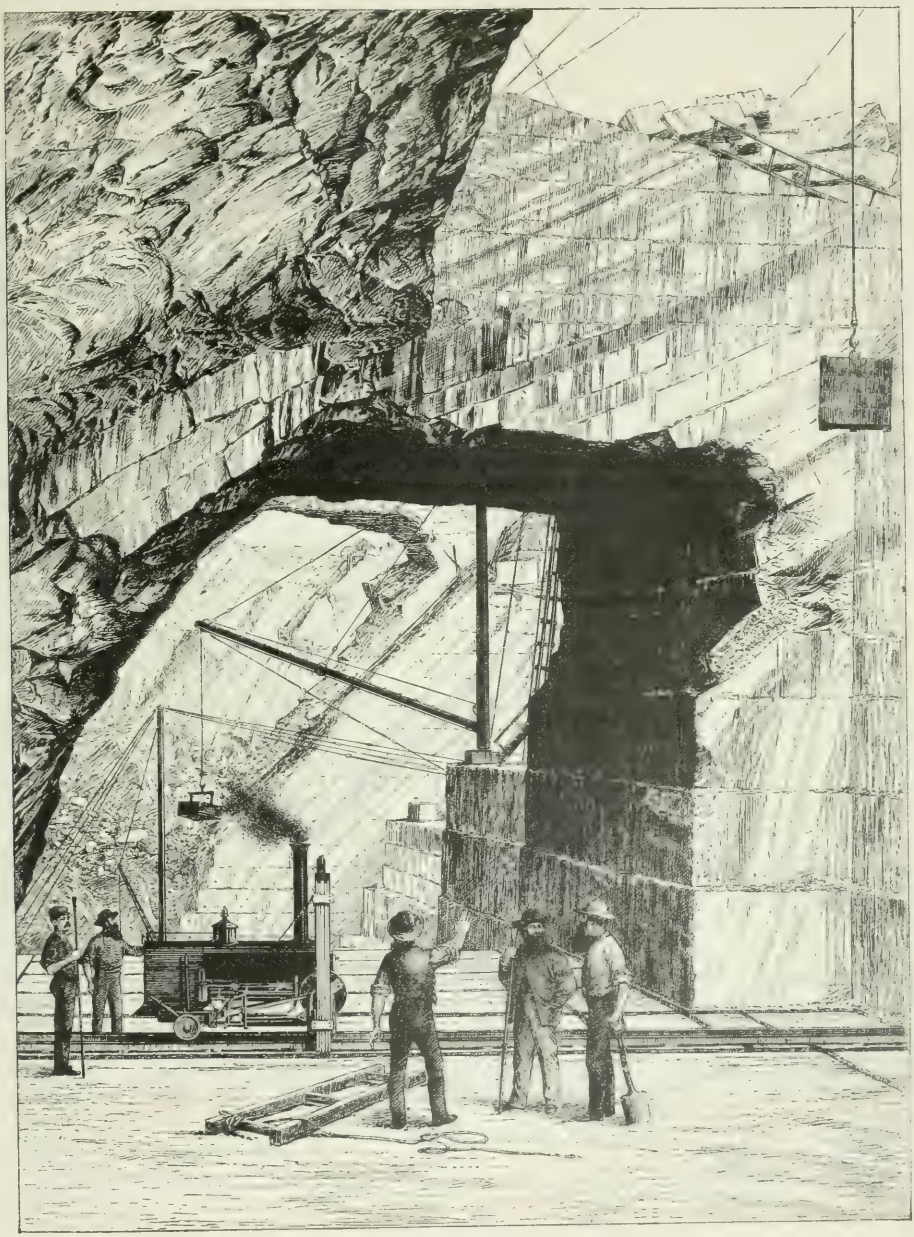
PLATE XXII.—Excavation in nearly horizontally stratified marble. The quarry floor is kept parallel with the stratification, and the channels are cut at right angles to the stratification with bars by hand or with the diamond channeling-machines. The roof is strong and capable of supporting itself over a wide span. However, the pillars left in these quarries are not sufficient to support the roof properly, and large masses of roof occasionally scale off and fall into the bottom of the quarries. It can hardly be hoped that no serious accident will ever result from these falls, though it is claimed that no person was ever injured by them.

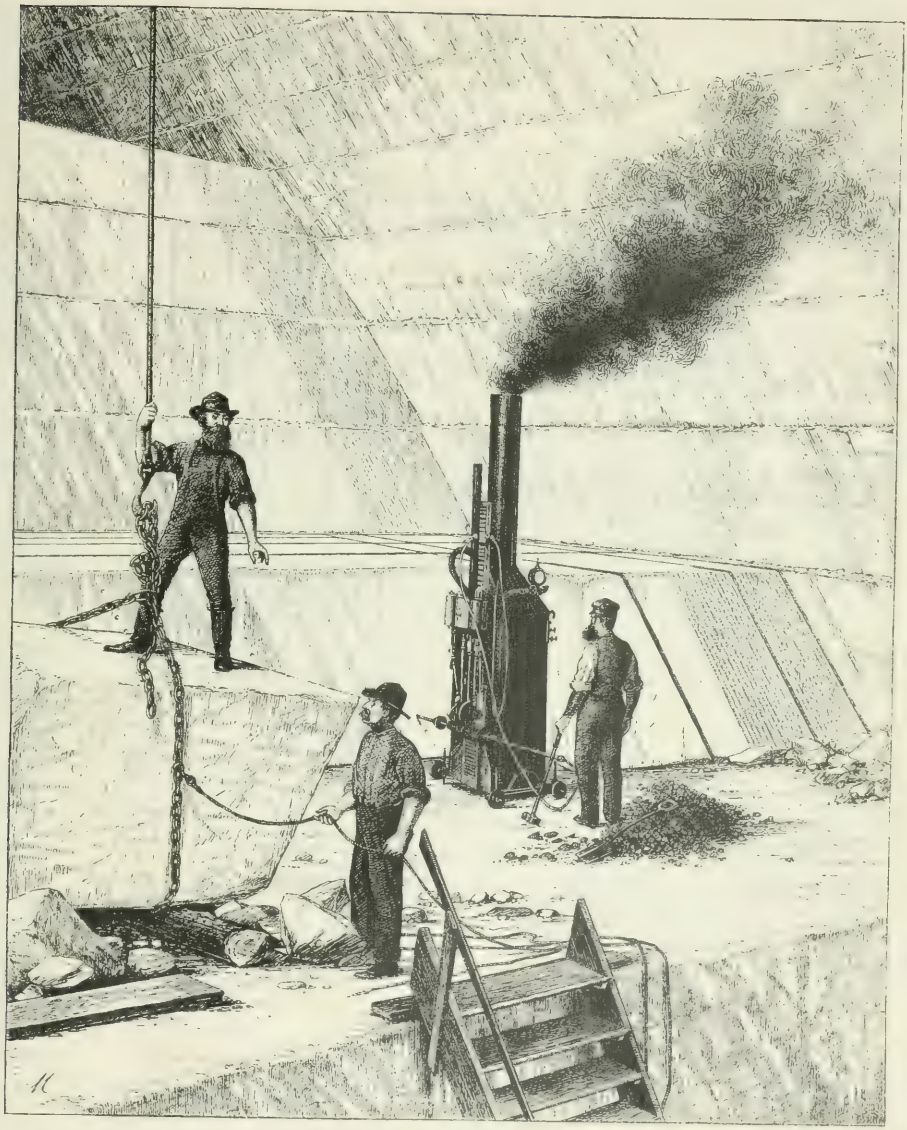
PLATE XXIII.—Illustration of the method of quarrying sandstone by channeling and wedging. The end of the quarry on the left of the picture is cut off by a channel about two feet in width, and the back of the quarry is cut off by a similar channel, so that a block may be detached by a row of wedges parallel to the first channel. Two men are driving a row of wedges, each man striking an alternate wedge as he moves forward. Two others, with picks, are cutting grooves for rows of wedges. The manner of splitting the blocks with the stratification is shown in the foreground to the right.

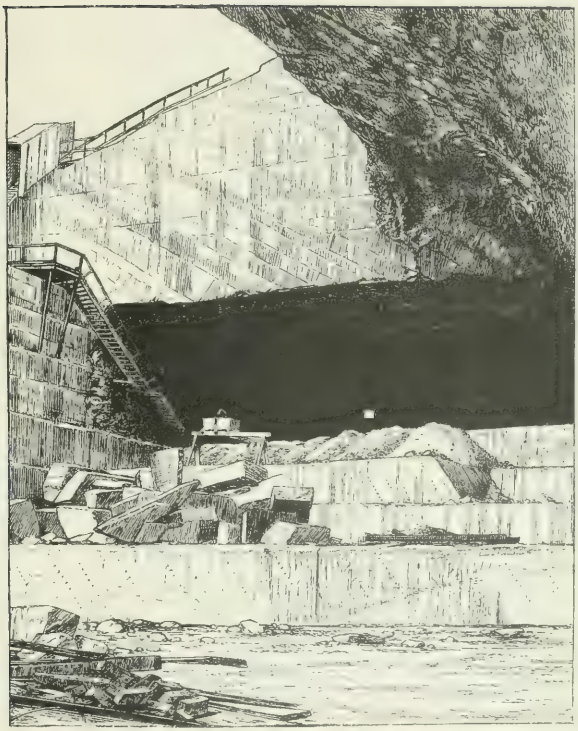
PLATE XXIV.—Greenstone or serpentine quarry. The rock is naturally much broken up by joints, and it is still more broken up by the powder with which it is quarried.

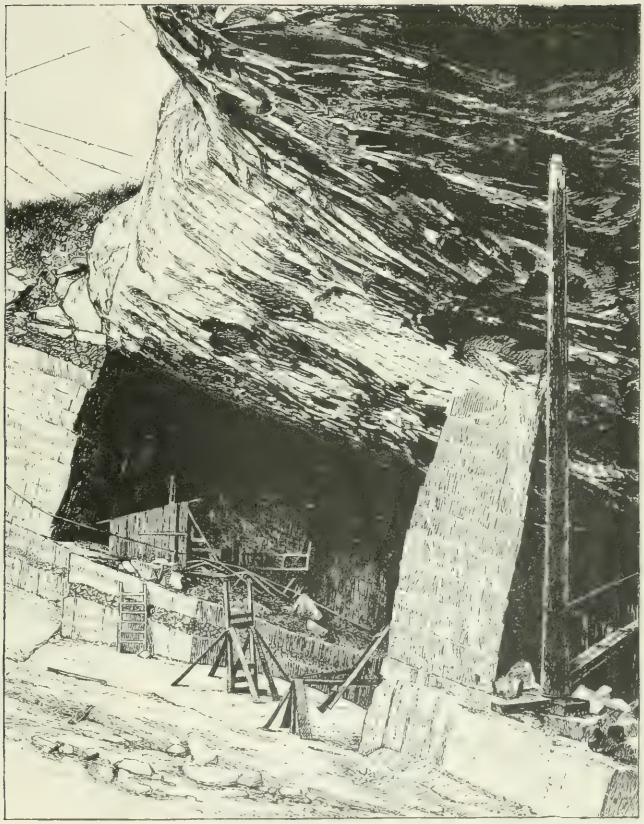
PLATE XXV.—Wardwell channeling-machine. For description, see page 35.

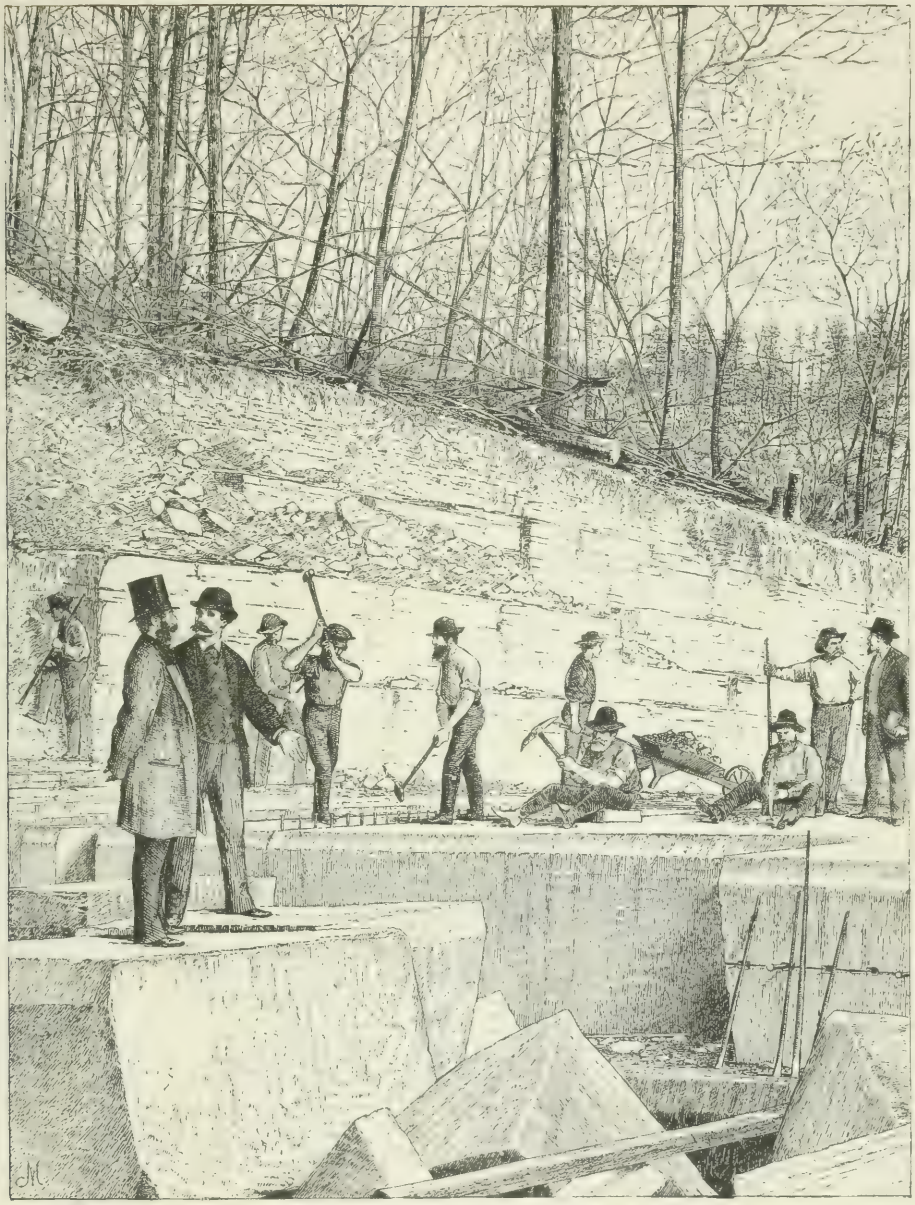
PLATE XXVI.—Two-spindle diamond channeling-machine. For description and use, see page 35.

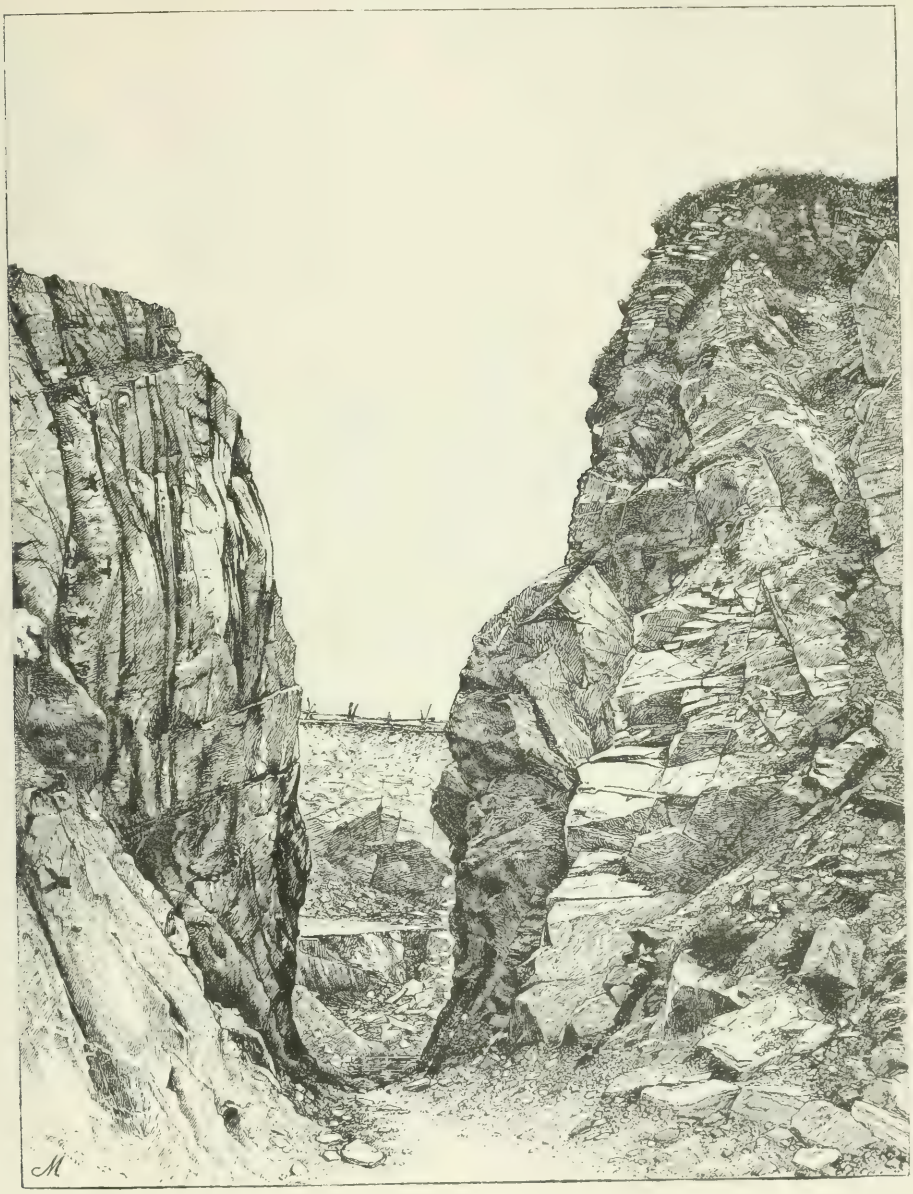


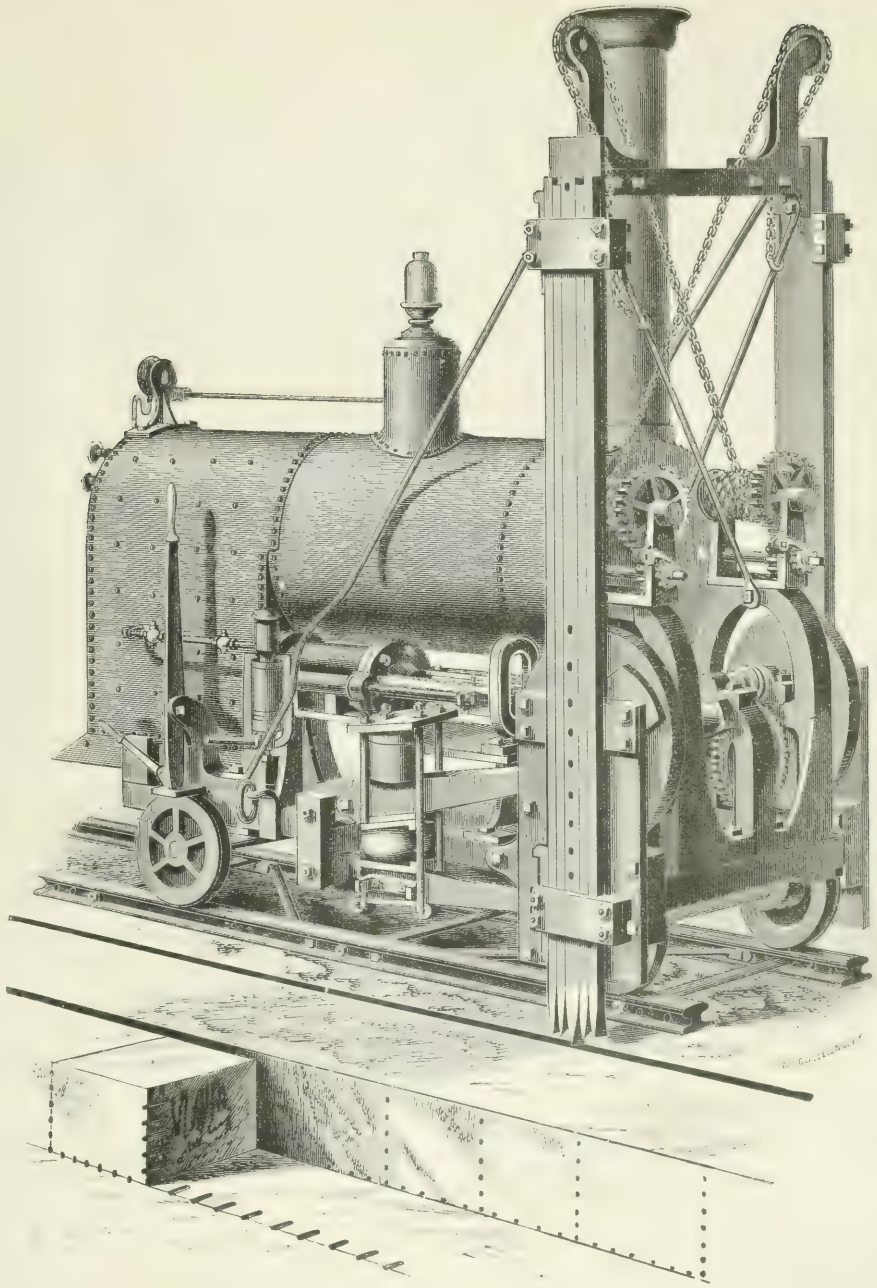


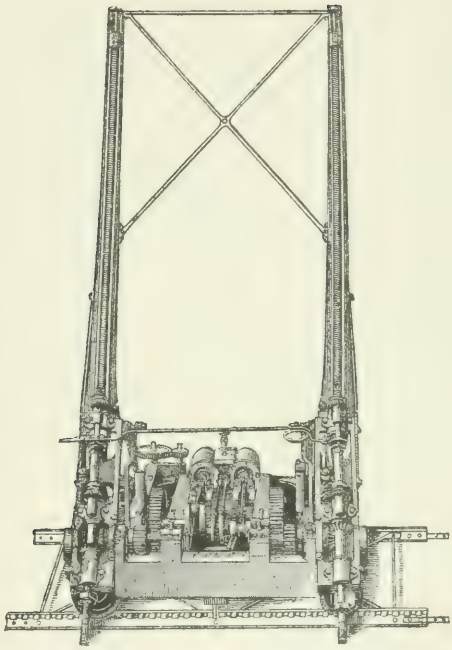












CHAPTER V.

STATISTICS OF BUILDING STONES.

TABLE I.—GENERAL STATISTICS OF THE QUARRYING INDUSTRIES OF THE UNITED STATES: 1880.

	States and Territories.	Number of quarries.	Capital invested.	Product in census year.	Value of product in census year.	Number of machines employed: For quarrying.	For hoisting.	For dressing.	Value of explosives used in census year.
			Dollars.	*Cubic feet.*	*Dollars.*				*Dollars.*
	Total for United States	1,525	25,414,497	115,380,133	18,356,055	339	2,290	1,368	192,175
	TOTALS BY KINDS OF ROCKS.								
1	Marble and limestone [a]	616	10,565,497	65,523,965	6,856,681	190	769	459	61,408
2	Sandstone	532	6,229,600	24,776,930	4,780,391	40	634	95	27,571
3	Crystalline siliceous rocks	313	5,291,250	20,506,568	5,188,998	64	763	322	70,397
4	Slate	94	3,328,150	4,572,670	1,529,985	45	184	392	32,799
	TOTALS BY STATES AND TERRITORIES.								
1	California	2	100,000	413,000	172,450	.....	6	14	1,000
2	Colorado	6	13,500	662,790	50,400	.....	8	.....	500
3	Connecticut	38	1,730,560	3,527,400	1,087,425	27	116	5	13,590
4	Dakota	1	3,500	38,400	12,000	.....	1	.....	324
5	Delaware	3	4,800	45,000	12,600	.....	3	.....	.....
6	Georgia	3	60,600	288,960	68,980	2	2	.....	615
7	Illinois	43	2,120,000	13,321,199	1,342,572	15	68	22	6,805
8	Iowa	131	556,775	10,929,783	670,754	2	109	11	6,859
9	Indiana	70	613,560	8,413,827	633,775	13	107	14	2,300
10	Kansas	19	73,700	1,406,346	142,570	.....	34	3	35
11	Kentucky	19	143,250	1,724,675	92,216	2	18	2	927
12	Maine	74	2,285,500	2,465,670	1,259,086	29	178	95	14,744
13	Maryland	17	307,935	1,375,917	346,629	4	31	19	5,725
14	Massachusetts	113	1,616,850	5,468,030	1,711,104	22	265	169	29,355
15	Michigan	9	74,700	648,060	79,165	.....	13	.....	1,222
16	Minnesota	41	284,225	3,169,113	255,818	.....	67	3	3,812
17	Missouri	34	328,550	4,699,600	613,171	6	29	6	3,050
18	Nebraska	1	5,000	330,000	15,000	.....	4	.....	125
19	New Hampshire	39	128,800	1,920,340	303,066	1	109	14	4,216
20	New Jersey	25	231,900	3,251,621	514,420	2	29	.....	2,596
21	New York	251	1,080,445	6,057,278	1,261,495	14	152	52	14,819
22	Ohio	245	4,166,802	19,673,309	2,541,647	16	447	79	18,763
23	Pennsylvania	164	3,077,885	15,310,184	1,944,208	56	173	213	33,820
24	Rhode Island	17	476,000	1,352,900	623,000	6	43	22	2,228
25	Tennessee	13	131,700	792,621	192,695	14	30	4	605
26	Vermont	61	4,732,040	2,468,150	1,752,333	88	183	537	12,300
27	Virginia	14	721,250	1,316,556	410,678	2	30	24	3,911
28	Washington	2	2,500	32,500	3,044	.....	1	.....	20
29	West Virginia	10	55,350	294,700	16,689	3	13	.....	696
30	Wisconsin	60	286,820	3,981,304	227,065	15	21	.....	7,213

[a] With "Marble and limestone" is included one quarry of serpentine rocks.

TABLE I.—GENERAL STATISTICS OF THE QUARRYING INDUSTRIES OF THE UNITED STATES: 1880.

NUMBER OF MONTHS IN OPERATION IN CENSUS YEAR.			NUMBER OF LABORERS EMPLOYED DURING CENSUS YEAR.					NUMBER OF ANIMALS EMPLOYED.			MEANS OF TRANSPORTATION.				
On full time.	On three-fourth time.	On one-half time.	Greatest number employed.	Males above 16 years of age.	Males below 16 years of age.	Employed in quarrying.	Employed in dressing.	Number of horses.	Number of mules.	Number of oxen.	Number of wagons.	Number of vessels	Number of cars.	Number of locomotives.	
13,021	286	112	39,723	38,945	778	25,726	9,840	8,059	851	1,096	3,685	265	651	5	
5,001	87	58	15,646	15,363	283	11,269	2,756	4,439	586	163	1,571	111	363	2	1
4,166	22	16	9,567	9,428	139	6,623	1,219	2,091	140	277	1,023	73	72	2	2
2,882	126	38	11,477	11,340	137	6,139	4,501	1,258	105	652	981	81	141	1	3
1,022	58	.....	3,033	2,814	219	1,695	1,364	271	20	4	110	.....	72	.....	4
23	.....	.....	195	194	1	50	160	8	.....	16	3	.....	.....	.....	1
60	.....	.....	134	134	.....	129	.....	17	5	.....	9	.....	.....	.....	2
341	36	2	1,902	1,883	19	1,369	466	112	54	266	455	46	15	.....	3
6	.....	3	35	35	.....	26	.....	18	.....	.....	9	.....	.....	.....	4
30	.....	.....	30	30	.....	.....	14	7	.....	.....	2	.....	.....	.....	5
36	.....	.....	146	143	3	84	50	6	44	.....	13	.....	.....	.....	6
314	4	.....	2,315	2,287	28	1,987	298	380	39	.....	177	41	51	.....	7
914	34	23	2,091	2,075	16	1,819	198	824	343	.....	160	8	40	.....	8
579	5	.....	1,788	1,701	87	1,121	142	545	.....	.....	153	.....	46	.....	9
158	.....	13	434	422	12	273	104	86	16	14	31	.....	.....	.....	10
160	2	1	806	791	15	486	140	199	.....	.....	57	1	.....	.....	11
606	31	17	4,011	3,936	75	1,793	2,058	241	.....	218	181	29	85	.....	12
153	22	.....	701	682	19	480	211	34	12	12	37	2	5	2	13
1,055	48	13	2,951	2,907	44	1,795	957	371	3	166	214	14	29	.....	14
73	.....	.....	200	190	10	187	13	56	.....	.....	15	2	2	.....	15
228	12	15	1,175	1,173	2	895	253	333	4	2	151	.....	.....	.....	16
316	6	4	783	764	19	437	122	71	96	.....	69	.....	6	.....	17
8	.....	.....	55	55	.....	40	15	22	.....	.....	.....	.....	.....	.....	18
325	16	4	595	595	.....	323	190	204	.....	84	114	3	7	.....	19
265	.....	.....	812	812	.....	615	130	85	6	37	68	5	.....	.....	20
2,186	6	3	3,302	3,220	82	2,426	656	774	23	24	429	12	22	.....	21
2,083	11	5	4,902	4,856	46	2,943	329	1,853	49	60	516	20	35	2	22
1,458	43	.....	4,284	4,078	206	2,904	1,212	819	57	.....	451	26	270	.....	23
166	.....	.....	962	953	9	342	418	134	.....	52	75	2	6	1	24
124	.....	.....	443	440	3	377	30	18	65	.....	26	2	.....	.....	25
627	5	.....	2,762	2,694	68	1,487	1,230	281	.....	131	130	38	5	.....	26
144	8	6	919	908	11	554	365	44	29	.....	34	.....	.....	.....	27
17	.....	.....	16	16	.....	10	6	.....	.....	.....	.....	.....	.....	.....	28
85	.....	.....	154	154	.....	75	42	28	.....	.....	11	3	20	.....	29
481	4	3	820	817	3	729	91	489	6	14	95	2	7	.....	30

TABLE II.—STATISTICS OF THE QUARRYING INDUSTRIES OF THE UNITED STATES, SHOWING NUMBER OF QUARRIES AND PRODUCTION, BY KINDS OF ROCK AND BY STATES AND TERRITORIES: 1880.

States and Territories.	Number of quarries.	Capital invested.	Product in census year.	Value of product in census year.
		Dollars.	*Cubic feet.*	*Dollars.*
Total United States	1,525	25,414,497	115,380,133	18,356,055
MARBLE AND LIMESTONE (a)	616	10,565,497	65,523,965	6,856,641
Illinois	38	2,101,200	13,013,139	1,320,742
Indiana	65	539,660	8,102,115	593,375
Iowa	128	552,775	10,772,283	666,554
Kansas	17	59,700	1,340,346	131,570
Kentucky	19	143,250	1,724,675	92,216
Maryland	3	142,435	70,617	65,929
Massachusetts	4	284,500	99,425	230,495
Michigan	4	61,050	97,800	26,085
Minnesota	33	159,575	2,816,298	201,593
Missouri	27	242,350	4,419,300	421,211
Nebraska	1	5,000	330,000	15,000
New York	55	508,620	2,836,025	431,439
Ohio	119	872,102	11,098,583	669,723
Pennsylvania (a)	24	592,160	3,339,722	240,934
Tennessee	13	131,700	792,621	192,695
Vermont	18	3,886,000	1,192,100	1,340,050
Virginia	2	35,000	20,000	27,750
Wisconsin	46	248,420	3,458,916	189,320
SANDSTONE	502	6,229,600	24,776,930	4,780,391
Colorado	3	2,000	108,750	9,000
Connecticut	6	1,167,500	988,200	680,200
Dakota	1	3,500	38,400	12,000
Illinois	5	18,800	308,060	21,830
Indiana	5	73,900	311,712	40,400
Iowa	3	4,000	157,500	4,200
Kansas	2	14,000	66,000	11,000
Massachusetts	15	95,800	729,980	144,294
Michigan	5	13,650	550,260	53,080
Minnesota	5	113,600	324,000	41,150
Missouri	5	51,200	194,000	81,960
New Jersey	20	210,100	2,384,791	400,420
New York	181	510,775	2,980,353	724,556
Ohio	126	3,294,700	8,574,726	1,871,924
Pennsylvania	95	560,825	6,229,110	627,943
Washington	1	1,500	14,000	2,000
West Virginia	10	55,350	294,700	16,689
Wisconsin	14	38,400	522,388	37,745
CRYSTALLINE SILICEOUS ROCKS	313	5,291,250	20,506,568	5,188,998
California	2	100,000	413,000	172,470
Colorado	3	11,500	554,040	41,400
Connecticut	32	563,060	2,539,200	407,225
Delaware	3	4,800	45,900	12,600
Georgia	2	60,000	278,960	64,480
Maine	68	1,625,500	2,203,670	1,175,286
Maryland	7	106,000	1,182,500	224,000
Massachusetts	92	1,217,150	4,623,125	1,529,315
Minnesota	3	11,050	28,815	13,075
Missouri	2	35,000	86,300	110,000

a With "Marble and limestone" is included one quarry of serpentine rocks.

TABLE II.—STATISTICS OF THE QUARRYING INDUSTRIES OF THE UNITED STATES—Cont'd.

States and Territories.	Number of quarries.	Capital invested.	Product in census year.	Value of product in census year.
CRYSTALLINE SILICEOUS ROCKS—Continued.		*Dollars.*	*Cubic feet.*	*Dollars.*
New Hampshire	39	128,800	1,920,340	393,066
New Jersey	2	10,500	820,000	99,000
New York	3	16,000	42,400	10,000
Pennsylvania	15	243,500	3,028,222	211,454
Rhode Island	17	476,000	1,352,900	623,000
Vermont	12	50,140	187,140	59,675
Virginia	10	631,250	1,181,556	331,928
Washington	1	1,000	18,500	1,044
			Squares.	
SLATE	94	3,328,150	457,267	1,529,985
Georgia	1	600	1,000	4,500
Maine	6	660,000	26,200	83,800
Maryland	7	59,500	12,280	56,700
Massachusetts	2	19,400	1,550	7,000
New Jersey	3	11,300	4,683	15,000
New York	12	45,050	19,850	95,500
Pennsylvania	39	1,681,400	271,313	863,877
Vermont	31	795,900	108,891	352,608
Virginia	2	55,000	11,500	51,060

TABLE III.—EXTENT TO WHICH BUILDING STONES AND SLATES ARE QUARRIED FOR APPLIANCES

LIMESTONE AND MARBLE.

	States and Territories.	Number of quarries.	Capital invested.	Total amount of excavation.	Product in census year.	Value of product in census year.	Number of machines employed: For quarrying.	For hoisting.	For dressing.	Value of explosives used in census year.	Number of months in operation in census year: On full time.	On three-quarter time.	On half time.
	The United States.	615	*Dollars.* 10,540,497	*Cubic yards* 50,529,854	*Cubic feet.* 65,373,905	*Dollars.* 6,846,681	190	706	497	*Dollars.* 61,358	4,995	87	58
1	Illinois	38	2,101,200	10,073,350	13,013,139	1,320,742	15	63	21	6,705	296	4	.....
2	Indiana	65	539,600	5,619,495	8,102,115	593,375	13	90	14	1,630	583	5	.....
3	Iowa	128	552,775	6,491,897	10,772,283	666,554	2	108	11	6,644	894	34	23
4	Kansas	17	59,700	219,390	1,340,346	131,570	.....	34	3	35	138	.....	13
5	Kentucky	19	143,250	934,460	1,724,675	92,216	2	18	2	927	160	2	1
6	Maryland	3	142,435	121,424	70,617	65,929	2	2	1	.....	17	.....	.....
7	Massachusetts	4	284,500	173,000	99,425	250,486	10	3	.....	35	39	4	.....
8	Michigan	4	61,000	501,180	97,800	26,085	.....	1	.....	600	30	.....	.....
9	Minnesota	33	159,575	1,305,149	2,816,208	201,593	.....	56	3	3,529	173	6	15
10	Missouri	27	242,350	822,775	4,440,360	423,241	.....	8	.....	2,525	254	6	4
11	Nebraska	1	5,000	200,000	350,000	15,000	.....	4	.....	125	8	.....	.....
12	New York	53	508,000	7,958,628	2,836,625	431,449	11	103	20	7,889	484	4	1
13	Ohio	119	872,102	7,881,563	11,098,583	689,723	10	62	.....	12,140	1,029	3	1
14	Pennsylvania (a)	23	567,160	4,192,000	3,189,722	230,964	16	27	2	7,215	232	9	.....
15	Tennessee	13	131,700	331,255	792,621	192,695	14	30	4	605	124	.....	.....
16	Vermont	18	3,886,000	2,438,858	1,192,100	1,340,050	83	81	404	3,071	170	2	.....
17	Virginia	2	35,000	1,280	20,000	27,750	.....	.....	12	.....	12	2	.....
18	Wisconsin	46	248,420	1,464,200	3,458,916	189,320	12	16	.....	6,730	400	4	.....

a The quarry of serpentine included in this group in Table II is here omitted.

SANDSTONE.

	The United States.	592	6,229,600	38,185,533	24,776,930	4,780,391	40	634	95	27,571	4,166	22	16
1	Colorado	3	2,000	10,000	108,750	9,000	.....	4	.....	230	24	.....	.....
2	Connecticut	6	1,167,500	4,357,000	988,200	680,200	18	26	.....	4,329	53	12	.....
3	Dakota	1	3,700	7,260	38,400	12,000	.....	1	.....	324	6	.....	3
4	Illinois	5	18,800	19,000	588,000	21,834	.....	5	.....	100	18	.....	.....
5	Indiana	5	73,900	107,730	311,712	40,400	.....	17	.....	610	46	.....	.....
6	Iowa	3	4,000	137,000	147,500	4,200	.....	1	.....	215	20	.....	.....
7	Kansas	2	14,000	17,000	60,000	11,000	.....	.....	.....	.....	20	.....	.....
8	Massachusetts	15	95,800	860,000	729,980	144,294	.....	19	1	2,026	144	2	6
9	Michigan	5	13,650	240,000	550,250	53,050	.....	12	.....	622	43	.....	.....
10	Minnesota	5	113,600	79,822	324,000	41,150	.....	6	.....	210	35	.....	.....
11	Missouri	5	51,200	425,185	194,000	81,000	4	15	5	35	41	.....	.....
12	New Jersey	29	210,100	2,384,000	2,054,791	400,420	2	23	.....	1,424	212	.....	.....
13	New York	181	510,775	7,727,523	2,980,353	724,556	.....	28	.....	4,229	1,737	.....	.....
14	Ohio	126	3,294,700	15,219,763	8,574,726	1,871,924	6	383	79	6,623	1,054	8	4
15	Pennsylvania	95	560,825	5,858,650	6,229,110	627,943	4	73	9	5,425	755	.....	.....
16	Washington	1	1,500	2,000	14,000	2,000	.....	1	.....	20	12	.....	.....
17	West Virginia	10	55,350	551,500	234,700	16,689	3	13	.....	696	85	.....	.....
18	Wisconsin	14	38,400	180,600	542,488	37,745	3	5	.....	483	81	.....	3

CRYSTALLINE SILICEOUS ROCKS.

	The United States.	314	5,291,250	27,090,841	20,506,508	5,188,998	64	706	322	70,267	2,832	126	38
1	California	2	100,000	377,000	413,000	172,470	.....	6	14	1,000	23	.....	.....
2	Colorado	3	11,500	114,000	554,040	41,400	.....	4	.....	300	36	.....	.....
3	Connecticut	32	561,060	1,832,900	2,539,200	407,225	9	90	5	9,261	288	24	2
4	Delaware	3	4,800	2,100	45,900	12,000	.....	3	.....	.....	30	.....	.....
5	Georgia	2	60,000	5,050,000	278,960	64,480	2	2	.....	515	24	.....	.....
6	Maine	68	1,625,500	1,997,436	2,203,670	1,175,286	20	166	74	9,494	556	22	17
7	Maryland	7	106,000	1,400,000	1,182,500	224,000	2	20	.....	3,275	67	13	.....
8	Massachusetts	92	1,217,150	5,988,165	4,623,125	1,329,315	11	242	168	26,694	856	34	7
9	Minnesota	3	11,050	14,851	28,815	13,075	.....	3	.....	80	20	4	.....
10	Missouri	2	35,000	125,500	26,300	110,000	2	6	1	480	21	.....	.....
11	New Hampshire	30	128,800	4,000,000	1,920,340	363,095	1	109	14	4,216	325	16	4
12	New Jersey	2	10,500	40,500	820,000	99,000	.....	2	.....	1,108	20	.....	.....
13	New York	3	16,000	98,822	42,000	10,000	3	3	.....	220	27	.....	2
14	Pennsylvania	15	243,500	4,000,000	3,028,522	211,454	5	15	.....	8,170	159	9	.....
15	Rhode Island	17	479,000	1,014,284	1,352,900	624,000	6	43	22	2,238	166	.....	.....
16	Vermont	12	59,140	241,500	187,140	59,675	1	17	16	215	99	.....	.....
17	Virginia	10	631,250	540,000	1,181,556	331,928	2	28	8	2,961	110	4	6
18	Washington	1	1,000	1,000	18,500	1,044	.....	.....	.....	.....	5	.....	.....

SLATE.

	The United States.	94	1,928,150	1,740,891	*a* 457,267	1,529,985	45	184	392	32,789	1,022	58	.....
1	Georgia	1	600	50,000	1,000	4,500	.....	.....	.....	100	12	.....	.....
2	Maine	6	660,000	440,000	26,200	84,800	9	12	21	5,250	50	9	.....
3	Maryland	7	59,500	403,310	12,280	56,700	.....	9	18	2,450	69	9	.....
4	Massachusetts	2	18,000	84,000	1,550	7,000	1	1	.....	440	16	8	.....
5	New Jersey	3	11,300	37,344	4,687	15,000	.....	4	.....	64	36	.....	.....
6	New York	12	45,050	1,198,100	19,850	95,500	.....	16	32	2,481	138	2	.....
7	Pennsylvania	8	1,681,400	6,383,437	271,313	863,877	31	55	200	12,960	324	25	.....
8	Vermont	41	795,900	4,973,800	108,891	352,608	4	85	117	8,114	358	3	.....
9	Virginia	2	55,000	170,000	11,500	51,000	.....	2	4	980	22	2	.....

a Squares.

PURPOSES OF CONSTRUCTION IN THE UNITED STATES, AND THE CAPITAL, LABOR, AND DEVOTED THERETO.

LIMESTONE AND MARBLE.

NUMBER OF LABORERS EMPLOYED DURING CENSUS YEAR.					NUMBER OF ANIMALS EMPLOYED.			MEANS OF TRANSPORTATION.				AVERAGE DAY'S WAGES.		
Greatest number employed.	Males above 16 years of age.	Males below 16 years of age.	Employed in quarrying.	Employed in dressing.	Number of horses.	Number of mules.	Number of oxen.	Number of wagons.	Number of vessels.	Number of cars.	Number of locomotives.	Skilled labor.	Unskilled labor.	
15,632	15,349	283	11,259	2,752	4,427	586	163	1,566	111	363	2	$2 24	$1 34	
2,208	2,181	27	1,913	265	355	38	.....	171	41	51	.....	2 41	1 55	1
1,698	1,573	65	1,054	132	504	.....	.....	137	.....	46	.....	2 32	1 30	2
2,018	2,002	16	1,786	102	798	323	.....	160	6	40	.....	2 04	1 35	3
404	392	12	257	101	82	8	2	23	.....	.....	.....	2 41	1 30	4
806	791	15	486	140	199	.....	.....	57	1	.....	.....	2 06	1 41	5
153	147	6	113	30	4	4	.....	8	.....	5	2	3 00	1 21	6
152	126	26	123	29	10	.....	10	7	.....	.....	.....	1 58	1 25	7
45	43	2	45	.....	30	.....	.....	10	2	.....	.....	.....	1 37	8
1,035	1,033	2	768	210	316	4	.....	140	.....	.....	.....	2 53	1 58	9
354	335	19	267	22	64	75	.....	59	.....	.....	.....	2 44	1 74	10
55	55	.....	40	15	22	.....	.....	.....	.....	.....	.....	2 75	1 75	11
1,291	1,269	22	744	442	326	21	24	186	5	22	.....	2 48	1 25	12
1,781	1,760	21	1,150	98	1,041	22	2	346	14	4	.....	2 00	1 20	13
642	632	10	577	36	128	20	.....	95	.....	187	.....	1 70	1 18	14
443	440	3	377	30	18	65	.....	26	2	.....	.....	1 76	1 05	15
1,896	1,862	34	915	943	103	.....	113	53	38	5	.....	1 93	1 15	16
51	51	.....	45	6	.....	.....	.....	.....	.....	.....	.....	2 50	1 05	17
660	657	3	599	61	427	6	12	88	2	3	.....	2 16	1 45	18

SANDSTONE.

9,567	9,428	139	6,623	1,219	2,089	140	277	1,023	73	72	2	$2 35	$1 46	
39	39	.....	39	.....	5	5	.....	2	.....	.....	.....	3 50	2 17	1
984	984	.....	791	172	43	41	160	282	25	.....	.....	1 98	1 29	2
35	35	.....	26	.....	18	.....	.....	9	.....	.....	.....	2 00	1 50	3
107	106	1	74	33	25	1	.....	6	.....	.....	.....	2 08	1 17	4
150	128	22	67	10	41	.....	.....	16	.....	.....	.....	3 00	1 50	5
73	73	.....	33	6	26	20	.....	.....	2	.....	.....	1 50	1 42	6
30	30	.....	16	3	4	8	12	8	.....	.....	.....	1 62	1 13	7
332	330	2	271	61	55	.....	8	32	.....	.....	.....	2 05	1 50	8
155	147	8	142	13	20	.....	.....	5	.....	2	.....	2 12	1 31	9
74	74	.....	59	15	14	.....	.....	7	.....	.....	.....	2 50	1 60	10
169	169	.....	90	15	4	15	.....	4	.....	.....	.....	2 19	1 56	11
582	582	.....	389	126	79	6	57	65	5	.....	.....	2 30	1 40	12
1,830	1,772	58	1,340	176	426	.....	.....	235	7	.....	.....	1 54	1 13	13
3,121	3,096	25	1,793	231	812	57	58	170	15	31	2	2 15	1 45	14
1,560	1,537	23	1,082	280	423	17	.....	164	16	15	.....	2 18	1 42	15
12	12	.....	6	6	.....	.....	.....	.....	.....	.....	.....	4 25	1 75	16
154	154	.....	75	42	28	.....	.....	11	3	20	.....	2 71	1 40	17
160	160	.....	130	30	62	.....	2	7	.....	4	.....	2 62	1 52	18

CRYSTALLINE SILICEOUS ROCKS.

11,477	11,340	137	6,139	4,501	1,258	105	652	981	81	144	1	$2 07	$1 36	
195	194	1	50	100	8	.....	16	3	.....	.....	.....	3 37	2 12	1
95	95	.....	90	.....	12	.....	.....	7	.....	.....	.....	2 66	2 00	2
918	899	19	578	294	69	13	106	173	21	15	.....	2 40	1 55	3
30	30	.....	.....	14	7	.....	.....	2	.....	.....	.....	2 00	1 25	4
136	133	3	77	47	3	44	.....	10	.....	.....	.....	2 50	95	5
3,800	3,733	67	1,712	1,975	206	.....	218	167	29	23	.....	1 81	1 25	6
422	412	10	203	129	28	2	12	58	2	.....	.....	2 58	1 28	7
2,445	2,429	16	1,363	836	206	3	148	175	14	29	.....	2 06	1 49	8
66	66	.....	28	38	4	.....	2	4	.....	.....	.....	2 53	1 62	9
260	260	.....	80	85	3	6	.....	6	.....	6	.....	2 08	1 33	10
595	595	.....	221	130	204	.....	84	114	3	7	.....	2 15	1 35	11
188	188	.....	184	4	.....	.....	.....	.....	.....	.....	.....	1 50	1 50	12
58	58	.....	58	9	3	.....	.....	.....	.....	.....	.....	3 00	1 58	13
437	437	.....	406	16	157	14	.....	130	10	58	.....	1 82	1 21	14
962	953	9	542	418	134	.....	52	75	2	6	1	1 78	1 24	15
111	110	1	104	1	86	.....	14	28	.....	.....	.....	2 15	1 19	16
775	764	11	447	328	29	23	.....	29	.....	.....	.....	2 22	97	17
4	4	.....	4	.....	.....	.....	.....	.....	.....	.....	.....	2 25	.....	18

SLATE.

3,033	2,814	219	1,695	1,364	271	20	4	110	.....	72	.....	$1 75	$1 17	
10	10	.....	7	3	3	.....	.....	3	.....	.....	.....	1 75	1 00	1
211	203	8	81	83	35	.....	.....	14	.....	62	.....	1 75	1 27	2
126	123	3	74	52	2	6	.....	1	.....	.....	.....	1 65	1 11	3
22	22	.....	18	4	.....	.....	.....	.....	.....	.....	.....	2 00	1 50	4
42	42	.....	42	.....	6	.....	.....	3	.....	.....	.....	1 75	1 21	5
143	141	2	114	29	19	2	.....	8	.....	.....	.....	1 57	1 25	6
1,631	1,458	173	829	836	99	6	.....	37	.....	10	.....	1 70	1 14	7
755	722	33	468	286	92	.....	4	39	.....	.....	.....	1 59	1 23	8
93	93	.....	62	31	15	6	.....	5	.....	.....	.....	2 00	80	9

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

NOTE.—It will be noted that the numbers of quarries represented in this table do not in all cases agree with those given in the tables preceding. This is due to the fact that the data for this table were not obtained for all quarries from which statistics of business were received, and, on the other hand, it was judged advisable, for various reasons, to introduce certain quarries here, although their product during the census year did not reach a valuation of $1,000.

MAINE—CRYSTALLINE SILICEOUS ROCKS.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
1	Red Beach	Washington	Maine Red Granite Company	Granite	Biotite granite
2	2 miles east of Jonesboro'	do	Bodwell Granite Company	do	do
3	4 miles southwest of Indian River	do	H. B. Nash (Diamond Granite Quarry)	do	Diabase
4	6 miles southeast of Addison Point	do	Pleasant River Black Granite Company	do	Olivine diabase
5	West Sullivan	Hancock	J. H. Stimpson	do	Biotite granite
6	West Sullivan	Hancock	Crabtree & Harvey	Granite	Biotite granite
7	do	do	Joseph H. West	do	do
8	Franklin	do	Blaisdell Brothers	do	do
9	2 miles south of Mount Desert	do	Whiting & Allen	do	do
10	2½ miles south of Mount Desert	do	C. J. Hall	do	do
11	East Bluehill	Hancock	Collins Granite Company	Granite	Biotite granite
12	do	do	G. W. Collins & Co	do	do
13	do	do	Chase & Hall	do	do
14	Deer Isle	do	Paul Thurlow & Co	do	do
15	do	do	Owens & McGee	do	do
16	Deer Isle	Hancock	Goss & Goss	Granite	Biotite granite
17	Green's Landing	do	James & C. A. Bayard	do	do
18	Frankfort	Waldo	Mount Waldo Granite Works	do	
19	Prospect	do	Edward Carey	do	
20	Swanville	do	Oak Hill Granite Company	do	Biotite granite
21	Lincolnville	Waldo	Beach Grove Granite Company	Granite	Muscovite-biotite granite
22	3 miles north by west of Vinal Haven	Knox	John S. Hopkins	do	Biotite granite
23	Vinal Haven	do	J. S. Black	do	do
24	do	do	Bodwell Granite Company	do	do
25	do	do	do	do	do
26	Vinal Haven	Knox	Bodwell Granite Company	Granite	Biotite granite (light); olivine diabase (dark).
27	Hurricane island	do	Davis Tilson	do	Biotite granite
28	Dix island	do	Dix Island Granite Company	do	do
29	South Thomaston	do	Ward & Woodward	do	do
30	do	do	Bodwell Granite Company	do	do
31	South Thomaston	Knox	Mirrick Sawyer	Granite	Biotite granite
32	do	do	M. T. Jamerson & Co	do	do
33	do	do	Nathan Stanton	do	do
34	4 miles east of Saint George	do	Atlantic Granite Company	do	do
35	3½ miles southeast of Saint George	do	Clark's Island Granite Company	do	do
36	Saint George	Knox	Wild Cat Granite Company	Granite	Biotite granite
37	do	do	Long Cove Granite Company	do	Hornblende-biotite granite (dark); biotite granite (light).
38	Waldoboro'	Lincoln	Day & Otis	do	Biotite granite
39	Jefferson	do	J. P. Glidden	do	Muscovite-biotite gneiss
40	Round Pond	do	Brown, McAllister & Co	do	Biotite granite
41	2½ miles east of Augusta	Kennebec	A. A. Young	Granite	Muscovite-biotite granite
42	2 miles west of Augusta	do	Kennebec Granite Company	do	do
43	Augusta	do	J. L. Dutton	do	do
44	do	do	Ward & Packard	do	do
45	2½ miles west of Hallowell	do	Hallowell Granite Company	do	do
46	Vassalboro	Kennebec	J. F. Gordon	Syenite	Biotite granite
47	2½ miles south of North Jewett	Somerset	Lawton Brothers	Granite	
48	3 miles south of North Jewett	do	Joseph Taylor	do	
49	3 miles northwest of Canaan	do	Sam. I. Fowler	do	Biotite granite
50	3 miles north of Canaan	do	Nathaniel Hall	do	do
51	North Berwick	Franklin	A. W. Woodman	Granite	Muscovite-biotite granite
52	do	do	Maine Central Railroad Company	do	do
53	do	do	Emerson & Bryant	do	do
54	4 miles northeast of Oberlin	do	J. H. Plummer	do	Biotite granite
55	Bryant's Pond	Oxford	Grand Trunk Railway	do	do
56	2 miles south of Lisbon	Androscoggin	C. H. Brandl	Granite	Biotite gneiss
57	3 miles south of Bar Mills	Cumberland	A. P. Woodside	do	Biotite granite
58	1 mile south of Powell	do	Charles H. Holsom	do	do
59	2 miles east of Buxton	do	Thomas S. Reed	do	do
60	Bradford	York	J. M. Andrews	do	do
61	Biddeford	York	C. H. Reardon	Granite	Biotite granite
62	do	do	C. H. & A. Goodwin	do	do
63	do	do	Gooch & Hume	do	do
64	Kennebunkport	do	Smith & Walker	do	do
65	7 miles northwest of Kennebunkport	do	George W. Ross	do	do
66	8 miles north of Kennebunkport	York	Francis Day	Granite	Biotite granite
67	9 miles north of Kennebunkport	do	Leavitt & Downes	do	do
68	4 miles southeast of South Berwick	do	Albert L. Goodwin	do	do

NOTE.—Thanks are due Mr. J. P. Iddings, of the United States Geological Survey, for aid in determining certain of the crystalline siliceous rocks of doubtful nature.

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

MAINE—Crystalline Siliceous Rocks.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Red	Coarse	Massive	Vertical, transverse, and horizontal.	Archæan		1875	1
...do	...do	...do	Vertical and horizontal	do		1870	2
Black	Fine	...do	Vertical and transverse	Devonian		1880	3
...do	...do	...do	...do	...do		1878	4
Light gray	...do	Indistinctly laminated	Horizontal and vertical	Archæan		1840	5
Light gray	Coarse	Massive	Inclined sheets	Archæan		1872	6
...do	Fine	...do	Irregular	...do		1876	7
...do	...do	...do	Vertical, transverse, and horizontal.	...do		1879	8
Light pinkish gray	...do	...do	Horizontal sheets	...do		1875	9
...do	Coarse	...do	Inclined sheets	...do		1871	10
Light pinkish gray	Fine	Massive	Irregular	Archæan		1873	11
Light gray	Coarse	...do	Inclined sheets	...do		1879	12
...do	...do	...do	...do	...do		1872	13
...do	...do	Indistinctly laminated	...do	...do		1877	14
...do	...do	...do	...do	...do		1870	15
Light gray	Coarse	Indistinctly laminated	Inclined sheets	Archæan		1871	16
...do	...do	...do	...do	...do		1878	17
Gray	Coarse, porphyritic	Massive	...do	...do		1853	18
...do	Coarse	...do	Horizontal sheets	...do		1871	19
...do	Fine	Indistinctly laminated	Horizontal and parallel, vertical.	...do		1873	20
White, or very light gray	Fine	Massive	Vertical and horizontal	Archæan		1876	21
Dark gray	Coarse	Indistinctly laminated	Horizontal sheets	...do		1872	22
Light gray	Fine	...do	...do	...do		1879	23
...do	Coarse	...do	Vertical, transverse, and horizontal.	...do		1857	24
...do	...do	...do	...do	...do		1858	25
Light gray and black	Fine	Indistinctly laminated	Horizontal sheets	Archæan		1850	26
Dark gray	Coarse, porphyritic	...do	Irregular	...do		1870	27
...do	Coarse	...do	...do	...do		1851	28
...do	Medium	...do	...do	...do		1878	29
...do	Coarse	...do	Horizontal sheets	...do		1860	30
Dark gray	Coarse	Indistinctly laminated	Horizontal sheets	Archæan		1859	31
...do	Fine	...do	Irregular	...do		1878	32
...do	...do	...do	...do	...do		1870	33
Gray	Fine, porphyritic	...do	...do	...do		1879	34
Dark gray	Fine	...do	Horizontal and parallel, vertical.	...do		1871	35
Dark gray	Fine	Indistinctly laminated	Horizontal and parallel, vertical.	Archæan		1874	36
Dark gray and black	...do	...do	Vertical, transverse, and horizontal	...do		1874	37
Gray	...do	...do	Horizontal sheets	...do		1830	38
Light gray	...do	Laminated	Irregular	...do		1876	39
Dark gray	...do	Indistinctly laminated	Broken, irregular	...do		1877	40
Gray	Fine	Massive	Horizontal sheets	Archæan		1873	41
...do	...do	...do	...do	...do		1877	42
...do	...do	...do	...do	...do		1856	43
...do	...do	...do	...do	...do		1876	44
White, or very light gray	...do	Indistinctly laminated	...do	...do		1800	45
Spotted, black, and white	Coarse	Massive	Irregular	Archæan		1860	46
Dark gray	Fine	...do	Horizontal sheets	...do		1866	47
...do	...do	Indistinctly laminated	Horizontal and parallel, vertical.	...do		1850	48
...do	Coarse	...do	Horizontal sheets	...do		1830	49
...do	...do	...do	...do	...do		1860	50
Light gray	Fine	Massive	Horizontal sheets	Archæan		1872	51
...do	...do	...do	...do	...do		1877	52
...do	...do	...do	...do	...do		1876	53
...do	...do	Indistinctly laminated	Horizontal and parallel, vertical.	...do		1845	54
Dark gray	...do	...do	Irregular	...do		1864	55
Dark gray	Fine	Laminated	Horizontal and vertical	Archæan		1856	56
Light gray	Coarse	Massive	Horizontal sheets	...do		1836	57
Gray	Fine	...do	...do	...do		1860	58
...do	...do	...do	...do	...do		1872	59
Light gray	Coarse, porphyritic	...do	Irregular	...do		1872	60
Gray	Coarse	Massive	Irregular	Archæan		1868	61
...do	...do	...do	Horizontal sheets	...do		1862	62
...do	...do	...do	Irregular	...do		1866	63
Light gray	...do	...do	Horizontal sheets	...do		1876	64
Gray	...do	...do	Irregular	...do		1868	65
Gray	Coarse	Massive	Irregular	Archæan		1869	66
...do	...do	...do	...do	...do		1878	67
...do	Fine	Indistinctly laminated	...do	...do		1878	68

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

MAINE—SLATE.

	Location of quarry.	County	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
1	Brownville	Piscataquis	Adams H. Merrill	Slate	
2	2 miles northwest of Brownville	do	Piscataquis Central Slate Company	do	
3	Monson	do	Monson Pond Slate Company	do	
4	do	do	Dexter Slate Company	do	
5	do	do	Hudson Pond Slate Company	do	
6	2 miles north of Blanchard	Piscataquis	Blanchard Slate Mining Company	Slate	

MASSACHUSETTS—CRYSTALLINE SILICEOUS ROCKS.

1	Gloucester	Essex	Stephen P. Andrews	Syenite	Hornblende-biotite granite
2	do	do	Cape Ann Granite Company	do	Hornblende granite
3	do	do	Trumble Granite Company	do	do
4	do	do	Sargent Granite	do	do
5	do	do	John Pattison	do	do
6	Gloucester	Essex	Parker Brothers	Syenite	Hornblende granite
7	do	do	Vinal & Bradley	do	do
8	Rockport	do	Rockport Granite Company	do	Hornblende-biotite granite
9	do	do	Cape Ann Granite Company	do	do
10	Lynn	do	J. R. Jordan	Granite	Hornblende granite
11	Lynn	Essex	J. D. Wilson	Granite	Hornblende granite
12	Peabody	do	Samuel Brown	Syenite	do
13	do	do	Perkins & Batchelder	do	do
14	do	do	Scott Brothers	do	do
15	do	do	H. A. Newhall	do	do
16	Lynnfield	Essex	Lucius R. Newhall	Syenite	Hornblende granite
17	do	do	J. J. Newhall	Granite	do
18	West Andover	do	J. Maddox	Bastard granite	Muscovite gneiss
19	Lawrence	do	Jesse Moulton	do	do
20	Lowell	Middlesex	S. L. Ward	Gneiss	Biotite gneiss (granitoid)
21	Medford	Middlesex	Town of Medford	Diabase	Diabase-microgranite
22	do	do	Nicholas White	do	do
23	Ashland	do	Judson W. Cole	Granite	
24	Holliston	do	J. C. Clovs	Porphyry	Biotite granite
25	Westfield	do	Andrew Fletcher	Granite	Muscovite gneiss (granitoid)
26	Westford	Middlesex	Prescott & Son	Granite	Muscovite gneiss (granitoid)
27	do	do	David Reed	do	do
28	do	do	Swett & Smith	do	Biotite-muscovite gneiss (granitoid)
29	do	do	Sol. Spaulding	do	do
30	do	do	Benjamin Palmer & Sons	do	Muscovite gneiss (granitoid)
31	Westford	Middlesex	William Reed	Granite	Muscovite gneiss (granitoid)
32	do	do	Samuel Hildreth	do	do
33	do	do	Joel	do	do
34	Lexington	Worcester	S. P. Locknold	do	Muscovite-biotite granite
35	do	do	Isaac Hall	do	Biotite granite
36	Leominster	Worcester	S. J. Kittredge	Granite	Biotite granite
37	Clinton	do	L. M. Allen	do	do
38	2 miles northeast of Worcester	do	G. D. Wells	do	Biotite-muscovite granite
39	14 miles northeast of Worcester	do	B. Converse	do	Muscovite granite
40	14 miles north of Milford	do	Richard Carroll	do	
41	Northbridge	Worcester	Diamond Hill Granite Company	Gneissoid granite	Biotite gneiss
42	do	do	Samuel Fowler, jr	do	do
43	do	do	George M. Blanchard	do	do
44	Charlton	do	Lamson & Woodbury	do	Muscovite gneiss
45	do	do	Stone & Hiscox	do	do
46	Northfield	Franklin	Bassett & Lyons	Gneissoid granite	Biotite gneiss
47	Deerfield	do	Westcott & Ames	Micaschist	Biotite schist
48	do	do	J. G. Noakes	do	do
49	Pittsfield	Berkshire	E. L. Humphrey	Limestone	Limestone
50	Becket	do	McClellan & Goodwin	Gneiss	Muscovite-biotite gneiss
51	Becket	Berkshire	Chester Granite Company (York & Baldwin)	Granite and gneiss	Muscovite-biotite gneiss
52	Monson	Hampden	W. N. Flint & Co	Gneiss	Biotite (dark) muscovite (light) gneiss (granitoid).
53	Brighton	Suffolk	S. W. Brown, jr	Blue-stone	Melaphyre
54	do	do	do	do	do
55	Dedham	Norfolk	M. Bullard	Porphyry	Epidote granite
56	Dedham	Norfolk	John Delaney	Porphyry	Epidote granite
57	Sharon	do	John Moyle	Granite	
58	Quincy	do	James Marks	Blue syenite	Hornblende granite
59	do	do	John O'Neal	do	do
60	do	do	Kennedy & Mahan	do	do
61	Quincy	Norfolk	Churchill & Hitchcock	Dark blue syenite	Hornblende granite
62	do	do	S. Dill	Blue syenite	do
63	do	do	Lee E. Faxon	Pink syenite	do
64	do	do	Barker & Sons	Pink and blue syenite.	do
65	do	do	McDonnell & Bros	Blue syenite	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

MAINE—Slate.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Bluish black	Fine	Rhomboidal	Irregular	Lower Silurian		1846	1
do	do	Rectangular	do	do		1875	2
do	do	Rectangular and irregular	Smooth	do		1879	3
do	do	Rhomboidal	do	do		1872	4
do	do	do	do	do		1871	5
Bluish black	Fine	Irregular	Even	Lower Silurian		1880	6

MASSACHUSETTS—Crystalline Siliceous Rocks.

Dark gray	Coarse	Massive	Irregular, broken	Archæan		1876	1
Light and dark gray	do	do	Few joints	do		1869	2
do	do	do	do	do		1870	3
do	do	do	do	do		1879	4
Dark gray	do	do	Irregular	do		1853	5
Dark gray	Coarse	Massive	Few joints	Archæan		1851	6
do	do	do	Irregular	do		1878	7
do	Medium	do	Horizontal and vertical	do		1830	8
do	do	do	do	do		1870	9
Dark greenish gray	Coarse	do	Horizontal, inclined, and vertical.	do		1850	10
Dark greenish gray	Coarse	Massive	Horizontal, inclined, and vertical.	Archæan		1860	11
Pinkish gray	do	do	Irregular	do		1841	12
Dark gray	do	do	Horizontal and irregular, vertical.	do		1872	13
do	do	do	do	do		1861	14
do	do	do	do	do		1871	15
Dark gray	Coarse	Massive	Few joints	Archæan		1870	16
do	do	do	Irregular	do		1861	17
do	Coarse, porphyritic	Laminated	Horizontal, vertical, and transverse.	do		1879	18
do	do	do	Horizontal and vertical	do		1847	19
do	Fine	do	Irregular	do		1876	20
Black	Coarse	Massive	Irregular	Lower Silurian		1872	21
do	do	do	do	do		1871	22
Gray	do	do	do	Archæan		1874	23
Pinkish gray	Coarse, porphyritic	do	do	do		1851	24
Light gray	Fine, porphyritic	Laminated	do	do		1880	25
Bluish gray	Fine	Laminated	Irregular	Archæan		1850	26
Pinkish gray	do	do	do	do		1854	27
Light gray	Fine, porphyritic	do	Horizontal and vertical	do		1845	28
do	do	do	do	do		1847	29
do	Fine	do	Irregular	do		1847	30
Dark gray	Fine	Laminated	Irregular	Archæan		1847	31
Pinkish gray	Fine, porphyritic	do	do	do		1847	32
Gray	Fine	Indistinctly laminated	do	do		1877	33
Light gray	do	do	do	do		1831	34
do	do	do	do	do		1876	35
Dark gray	Fine	Indistinctly laminated	Irregular	Archæan		1872	36
do	do	Massive	do	do		1875	37
Light gray	Medium	do	do	do		1830	38
do	do	do	Irregular, broken	do		1870	39
Reddish yellow	do	do	Horizontal, vertical, and transverse.	do		1869	40
Light gray	Medium	Indistinctly laminated	Irregular	Archæan		1855	41
do	do	do	Few joints	do		1869	42
do	do	do	Irregular	do		1865	43
do	do	do	Parallel, vertical, and inclined.	do		1864	44
do	do	do	do	do		1879	45
Light gray	Fine	Indistinctly laminated	Horizontal, inclined, and vertical.	Archæan		1875	46
Rusty brown	do	Laminated	Inclined, vertical, and transverse.	Upper Silurian		1880	47
do	do	do	do	do		1880	48
Light blue	Coarse	do	Vertical, transverse, and inclined.	Lower Silurian		1871	49
Light gray	Fine	do	Irregular, broken	Archæan		1880	50
Light gray	Fine	Laminated	Horizontal and vertical	Archæan		1878	51
Light and dark gray	do	do	Horizontal sheets	do		1839	52
Dark greenish blue	do	Indistinctly laminated	Irregular, broken	do		1878	53
do	do	do	do	do		1850	54
Red	Fine, porphyritic	Massive	Irregular	do		1870	55
Red	Fine, porphyritic	Massive	Irregular	Archæan		1868	56
Light blue	Coarse	do	do	do		1874	57
Blue	do	do	do	do		1831	58
do	do	do	do	do		1876	59
do	do	do	do	do		1878	60
Dark blue	Coarse	Massive	Irregular	Archæan		1840	61
Blue	do	do	do	do		1875	62
Pink	do	do	do	do		1862	63
Pink and blue	do	do	do	do		1834	64
Blue	do	do	Irregular and broken	do		1832	65

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

MASSACHUSETTS—CRYSTALLINE SILICEOUS ROCKS—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
66	Quincy	Norfolk	E. De Gruney	Blue syenite	Hornblende granite
67	do	do	C. Dunn	Blue granite	do
68	do	do	E. Baker	do	do
69	do	do	Lewis Dill	do	do
70	do	do	Wild & Field	do	do
71	Quincy	Norfolk	Hector Murry	Gray granite	Hornblende granite
72	do	do	McKinza & Patterson	Blue granite	do
73	do	do	H. Farnum	Syenite	do
74	do	do	William Moore	do	do
75	do	do	James Garrity	Blue syenite	do
76	Quincy	Norfolk	C. Hardwicke & Co	Blue syenite	Hornblende granite
77	do	do	Frederick & Field	do	do
78	do	do	Wendell & Co	Granite	do
79	do	do	William Tranior	Blue syenite	do
80	do	do	Charles Johnson	do	do
81	Quincy	Norfolk	E. Roberts & Co	Blue syenite	Hornblende granite
82	West Quincy	do	Elwick & Sons	Syenite	do
83	do	do	James Berry	do	do
84	do	do	Walter Berry	do	do
85	do	do	F. J. Fuller & Co	do	do
86	West Quincy	Norfolk	O. T. Rogers & Co	Syenite	Hornblende granite
87	do	do	Granite Railroad Company	do	do
88	do	do	Charles Wilson	do	Hornblende granite
89	Randolph	do	S. B. Corliss	Granite	Biotite granite
90	Brockton	Plymouth	W. T. Cleveland	do	do
91	Fall River	Bristol	William Beatty	Granite	Biotite granite
92	do	do	Nathaniel Thurston	do	do
93	Freetown	do	Fall River Granite Company	do	do

MASSACHUSETTS—MARBLE AND LIMESTONE.

1	Pittsfield	Berkshire	E. L. Humphrey	Granite	Magnesian limestone
2	Lee	do	F. S Gross	Marble	Dolomite
3	Alford	do	Horace S. Fitch	do	Limestone
4	Sheffield	do	Briggs Company	do	Magnesian limestone

MASSACHUSETTS—SANDSTONE.

1	Lowell	Middlesex	W. E. Livingstone	Mortar stone	
2	do	do	City of Lowell	do	
3	Newton	do	Patrick Grace	Pudding stone	
4	Brighton	Suffolk	J. Welch	do	
5	Boston Highlands	do	Owen Mawn	do	
6	Boston Highlands	Suffolk	Michael Leonard	Pudding stone	
7	do	Norfolk	T. McCarty	do	
8	do	do	Hugh Anan	do	
9	Deerfield	Franklin	James Smith	Sandstone	
10	do	do	Blake Brothers	do	
11	Northampton	Hampshire	John Delaney	Sandstone	
12	Holyoke	Hampden	L. P. Bosworth	do	
13	West Springfield	do	Curtis D. Stoddard	do	
14	Longmeadow	do	S. J. Billings & Co	do	
15	do	do	Norcross Bros. & Taylor	do	

MASSACHUSETTS—SLATE.

1	Cambridge	Middlesex	City of Cambridge	Slate	
2	Lancaster	Worcester	Lancaster Slate Company	do	

RHODE ISLAND—CRYSTALLINE SILICEOUS ROCKS.

1	Pascoag	Providence	Garvey Brothers	Gneissoid granite	Biotite gneiss
2	Woonsocket	do	Fairmount Farm Company	Mica schist	Biotite schist
3	Diamond Hill	do	Diamond Hill Granite Company	Gneissoid granite	Hornblende gneiss
4	Smithfield (4 miles east of)	do	Smithfield Granite Company	Granite	Biotite granite
5	Cranston	do	Richard Turner	Mica schist	Mica schist
6	West Greenwich	Kent	Horace Vaughn	Granite	Biotite granite
7	do	do	Joseph Talbot	do	do
8	do	do	James Ray	do	do
9	Newport	Newport	J. S. Stacey	do	do
10	2 miles east of Westerly	Washington	Charles P. Chapman	do	do
11	2 miles east of Westerly	Washington	New England Granite Works	Granite	Biotite granite
12	do	do	Smith Granite Company	do	do
13	do	do	do	do	do
14	do	do	Charles P. Chapman	do	do
15	do	do	John R. Macomber	do	do
16	2 miles east of Westerly	do	R. L. Means	Granite	Biotite granite
17	Niantic	do	A. G. Crumb & Co	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

MASSACHUSETTS—Crystalline Siliceous Rocks—Continued.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Blue	Coarse	Massive	Irregular and broken	Archæan		1879	66
do	do	do	Vertical and horizontal	do		1879	67
do	do	do	do	do		1879	68
do	do	do	do	do		1857	69
do	do	do	Irregular	do		1810	70
Gray	Coarse	Massive	Irregular	Archæan		1840	71
Blue	do	do	do	do		1818	72
do	do	do	do	do		1878	73
do	do	do	do	do		1874	74
Dark gray	do	do	do	do		1868	75
Dark gray	Coarse	Massive	Irregular	Archæan		1810	76
do	do	do	do	do		1839	77
Gray	do	do	do	do		1820	78
Blue	do	do	do	do		1850	79
do	Medium	do	do	do		1845	80
Blue	Medium	Massive	Irregular	Archæan		1808	81
do	Coarse	do	Irregular, broken	do		1870	82
do	do	do	do	do		1850	83
do	do	do	do	do		1827	84
do	Medium	do	Horizontal and vertical	do		1840	85
Blue	Medium	Massive	Horizontal and vertical	Archæan		1826	86
do	do	do	Vertical, horizontal, and inclined.	do		1826	87
Dark gray	Coarse	do	Irregular	do		1852	88
Red	Medium	do	do	do		1872	89
do	do	do	do	do		1879	90
Gray	Medium	Massive	Horizontal, vertical, and transverse.	Archæan		1840	91
do	do	do	do	do		1873	92
do	do	do	Horizontal and vertical	do		1874	93

MASSACHUSETTS—Marble and Limestone.

Gray	Coarse crystalline	Irregular	Uneven, thick	Lower Silurian	1871	1
White	Coarsely crystalline	Massive	do	do	1852	2
Bluish white	Crystalline	do	do	do	1843	3
White	do	do	do	do	1845	4

MASSACHUSETTS—Sandstone.

Green	Fine	Irregular	Uneven, thick	Archæan	1850	1
do	do	do	do	do	1856	2
Light blue	Coarse, conglomerate	Massive	Thick	Lower Silurian	1880	3
Blue	do	do	do	Archæan	1878	4
do	Coarse	do	do	Lower Silurian	1878	5
Blue	Coarse	Massive	Thick	Lower Silurian	1860	6
do	do	do	do	do	1840	7
do	do	do	do	do	1850	8
Red	do	do	Uneven, thick	Triassic	1880	9
do	do	do	do	do	1880	10
Dark brown	Coarse	Massive	Even, thick	Triassic	1840	11
Dark rusty brown	do	do	do	do	1874	12
Reddish brown	Inferior	Irregular	do	do	1850	13
Red	Fine, even	Massive	do	do	1867	14
do	do	do	do	do	1800	15

MASSACHUSETTS—Slate.

Dark blue	Very fine	Irregular	Even	Archæan	1841	1
Bluish black	Porous	Rectangular	Stratification lines distinct	do	1879	2

RHODE ISLAND—Crystalline Siliceous Rocks.

Pink, black, and white	Coarse	Massive	Parallel and vertical	Archæan	1873	1
Blue to green	Fine to coarse	Laminated	do	do	1859	2
Blue and bluish black	Medium	do	do	do	1840	3
Light pink	Coarse	Massive	do	do	1871	4
Bluish black	Variable	Laminated	Irregular	Carboniferous?	1820	5
Red	Coarse	Massive	Parallel and vertical	Archæan	1865	6
do	do	do	do	do	1853	7
Black and white	Fine	do	do	do	1877	8
Red	Medium fine	do	Irregular	do	1855	9
Red and blue	Fine	Indistinctly laminated	Parallel and vertical	do	1862	10
Red, white, and blue	Fine	Indistinctly laminated	Parallel and vertical	Archæan	1850	11
White and blue	do	do	Irregular and vertical	do	1843	12
Red	Medium coarse	Massive	Few joints	do	1850	13
White and blue	Fine	do	Parallel and vertical	do	1874	14
Gray, red, and white	Medium coarse	do	Irregular	do	1860	15
White	Medium coarse	Massive	Few joints	Archæan	1879	16
do	Fine	do	Vertical	do	1859	17

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

NEW HAMPSHIRE—CRYSTALLINE SILICEOUS ROCKS.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
1	Plymouth	Grafton	Jarvis Sanborn	Granite	Biotite granite
2	Lebanon	do	Charles Freeman	Granite gneiss	Biotite-epidote gneiss
3	do	do	D. H. Lewis & Son	Granite	do
4	Hebron	do	David L. Tilton	do	Biotite granite
5	Bramley	do	George D. Kenaston	do	Biotite-muscovite granite
6	Sunapee	Sullivan	Charles E. Boyce	Granite	Biotite-muscovite granite (light and dark).
7	West Concord	Merrimack	Putney & Nutting	do	Biotite-muscovite granite
8	do	do	Crowell & Quinn	do	do
9	do	do	George A. Epsworth	Concord granite	do
10	Concord	do	Donegan & Davis	Granite	do
11	Concord	Merrimack	Abijah Hollis	Granite	Biotite-muscovite granite
12	do	do	Harrison Granite Company	do	do
13	do	do	M. H. Johnson	do	do
14	do	do	Titus & Hodgman	do	do
15	do	do	Tullet & Priesy	do	do
16	Concord	Merrimack	Granite Railway Company	Granite	Biotite-muscovite granite
17	Avery town	do	Charles A. Bailey	do	do
18	Portsmouth	Strafford	Joseph S. Abbott	Syenite	Biotite granite
19	Raymond	Rockingham	Aaron F. Keys	Granite	do
20	Peterborough	Hillsborough	Dennis O'Keefe	Gneiss	Muscovite-biotite gneiss
21	Milford	Hillsborough	Kittredge & Carlton	Granite	Biotite granite
22	do	do	Everett & Hutchinson	do	do
23	do	do	Thomas Ivins	do	do
24	do	do	Nathan Merrill	do	do
25	do	do	George F. Parker	do	do
26	2 miles southwest of Milford	Hillsborough	L. M. Burns	Granite	Biotite granite
27	2 miles northwest of Milford	do	A. D. Bates	do	do
28	Mason	do	James Maxwell	do	do
29	do	do	William Braman	do	do
30	do	do	Alexander MacDonald	do	do
31	Nashua	Hillsborough	C. W. Stevens	Gneiss	Muscovite granite
32	Manchester	do	Amoskeag Manufacturing Company	Granite	Biotite granite
33	Pittsfield	Chesshire	D. H. Lord	do	Muscovite-biotite granite
34	do	do	R. L. Angier & Co	Granitic gneiss	Biotite granite
35	do	do	Melvin Wilson	do	Muscovite-biotite granite (light); biotite granite (dark).
36	Fitzwilliam	Cheshire	Fitam Blodgett	Granite	Biotite granite (dark)
37	do	do	John E. Fisher	do	Muscovite-biotite granite
38	do	do	Albert Hayden	Granitic gneiss	Muscovite-biotite gneiss
39	Marlborough	do	Albert G. Mann	Granite	Muscovite-biotite granite

VERMONT—CRYSTALLINE SILICEOUS ROCKS.

1	Brunswick	Essex	Sand Johnsbury Granite Company	Granite	Biotite granite
2	Morgan	Orleans	D. T. Turner & Son	do	do
3	Barre	Caledonia	R. F. Carter	do	Biotite-muscovite granite
4	do	do	R. W. Laird	do	do
5	2 miles northeast of Woodbury	Washington	C. W. Cilley	do	Biotite granite
6	Woodbury	Washington	J. Ainsworth & Son	Granite	Biotite granite
7	do	do	Vondry & Towne	do	do
8	Barre	do	E. L. Smith	do	do
9	do	do	G. W. Mann	do	do
10	do	do	Wetmore & Morse	do	do
11	Bethel	Windsor	Edwin Kittredge	Granite	Muscovite biotite (dark); muscovite granite (light).
12	do	do	E. Sturtevant & Co	do	Muscovite granite

VERMONT—MARBLE AND LIMESTONE.

1	Swanton	Franklin	G. & R. L. Barney	Lyonnaise marble	Magnesian limestone
2	Isle La Motte	Grand Isle	Ira & I. P. Hill	Marble and limestone	do
3	do	do	Estate of Peter Fleury	do	do
4	do	do	Goodsell & Hursh	Limestone and marble.	do
5	do	do	H. C. Fisk & Son	do	do
6	Pittsford	Rutland	F. W. Smith & Co	Marble	Magnesian limestone
7	Rutland	do	Flint Brothers & Co	do	Magnesian limestone and calcareous dolomite.
8	do	do	Sutherland Falls Marble Company	do	Limestone
9	do	do	Columbian Marble Company	do	do
10	West Rutland	do	Rutland Marble Company	do	do
11	do	Rutland	Gilson & Woodfin	Marble	Limestone
12	do	do	Shelburne & Sloson	do	do
13	do	do	Sherman & Gleason	do	do
14	South Wallingford	do	William W. Kelly	do	do
15	Dorset	Bennington	S. F. Prince & Co	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

NEW HAMPSHIRE—Crystalline Siliceous Rocks.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
.....	Fine	Massive	Horizontal sheets	Archæan		1870	1
Light pink	Medium	Obscurely stratified	Horizontal and vertical	...do		1865	2
Gray	Coarse	Indistinctly laminated	...do	...do		1844	3
...do	...do	Massive	Horizontal sheets	...do		1870	4
...do	Fine	...do	...do	...do		1870	5
.....	Fine	Massive	Inclined sheets	Archæan		1846	6
Gray	...do	...do	Horizontal and vertical	...do		1851	7
...do	...do	...do	...do	...do		1866	8
...do	...do	...do	Irregular	...do		1870	9
.....	...do	...do	Horizontal and vertical	...do		1866	10
.....	Fine	Massive	Horizontal and vertical	Archæan		1865	11
Gray	...do	Indistinctly laminated	...do	...do		1875	12
.....	...do	Massive	...do	...do		1870	13
Gray	...do	Indistinctly laminated	Horizontal sheets	...do		1874	14
...do	...do	Massive	Horizontal and vertical	...do		1867	15
Gray	Fine	Massive	Horizontal sheets	Archæan		1862	16
...do	Medium	...do	Horizontal and vertical	...do		1876	17
...do	Coarse	...do	Inclined sheets	...do		1871	18
Light pink	Medium	Indistinctly laminated	...do	...do		1870	19
.....	Coarse	Laminated	...do	...do		1870	20
Gray	Medium	Indistinctly laminated	Irregular	Archæan		1877	21
...do	Fine	...do	...do	...do		1871	22
...do	...do	...do	Vertical and transverse	...do		1871	23
...do	Coarse	Massive	...do	...do		1874	24
.....	Fine	Indistinctly laminated	Irregular	...do		1870	25
.....	Coarse	Massive	Horizontal sheets	Archæan		1820	26
.....	Fine	Indistinctly laminated	Vertical and transverse	...do		1855	27
.....	Medium	...do	Solid	...do		1875	28
Gray	...do	...do	Horizontal and vertical	...do		1860	29
...do	Fine	...do	...do	...do		1860	30
.....	Coarse	Indistinctly laminated	Irregular	Archæan		1822	31
Pink	...do	...do	Horizontal and vertical	...do		1874	32
Gray	Fine	Massive	Horizontal sheets	...do		1864	33
Light and dark gray	...do	...do	Inclined sheets	...do		1864	34
Gray	...do	...do	Horizontal sheets	...do		1860	35
Gray	Fine	Massive	Irregular	Archæan		1868	36
...do	Medium	...do	Horizontal and vertical	...do		1870	37
...do	Fine	Indistinctly laminated	...do	...do		1870	38
...do	...do	Massive	Inclined sheets	...do		1812	39

VERMONT—Crystalline Siliceous Rocks.

Dark gray	Fine	Massive	Rectangular	Archæan		1854	1
Light gray	...do	Indistinctly laminated	Vertical and transverse	Upper Silurian		1870	2
Gray	Coarse	...do	Vertical joints	...do		1875	3
Light gray	Fine	Laminated	Horizontal and vertical joints.	...do		1880	4
Light pinkish gray	Medium	Indistinctly laminated	Inclined sheets	...do		1880	5
Light pinkish gray	Medium	Indistinctly laminated	Horizontal and vertical joints.	Upper Silurian		1876	6
Light gray	...do	Massive	Parallel vertical joints	...do		1879	7
...do	Fine	...do	Horizontal and vertical joints.	...do		1875	8
Dark gray	...do	...do	Horizontal and parallel vertical joints.	...do		1878	9
Light gray	Medium	...do	Horizontal and vertical joints.	...do		1840	10
Light gray	Fine	Massive	Inclined sheets	Upper Silurian		1868	11
...do	Medium	...do	Parallel vertical joints	...do		1879	12

VERMONT—Marble and Limestone.

Red, variegated	Coarse and fine	Massive	Thick	Lower Silurian		1866	1
Black, gray, and variegated	Fine	...do	Even, thick	...do		1874	2
...do	Coarse	...do	Thick	...do		1880	3
...do	Coarse and fine	...do	Even thick	...do		1874	4
...do	...do	...do	...do	...do		1776	5
White to dark blue	Fine	Massive	Even thick	Lower Silurian		1880	6
White with dark shades	...do	...do	Thick	...do		1866	7
White with dark bands and streaks	...do	...do	...do	...do		1850	8
White with dark shades	...do	...do	...do	...do		1867	9
White to dark blue	...do	...do	...do	...do		1845	10
White and blue	Fine	Massive	Thick	Lower Silurian		1845	11
...do	...do	...do	...do	...do		1844	12
White and mottled	...do	...do	Obscure	...do		1844	13
White	...do	...do	Even, thick	...do		1867	14
White and mottled	...do	...do	...do	...do		1850	15

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

VERMONT—MARBLE AND LIMESTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
16	Dorset	Bennington	Freedly & Son	Marble	Limestone
17	East Dorset	do	Hollister, Tyrell & Co. (New Dorset Marble Company).	do	
18	do	do	D. L. Kent & Co	do	Magnesian limestone

VERMONT—SLATE.

1	Northfield	Washington	Adams Slate and Tile Company	Slate	
2	Castleton	Rutland	Richard Conway	do	
3	do	do	Clifford & Litchfield	do	
4	do	do	Lake Shore Slate Company	do	
5	do	do	Blue Slate Company	do	
6	Castleton	Rutland	Snowden Slate Company	Slate	
7	Fair Haven	do	Pierce Roberts	do	
8	do	do	Jones, Owens & Co	do	
9	do	do	Vermont Union Slate Company	do	
10	do	do	Fair Haven Marble and Marbleized Slate Company.	do	
11	Fair Haven	Rutland	Griffiths, Owen & Co. (north quarry)	Slate	
12	do	do	Griffiths, Owen & Co. (south quarry)	do	
13	Poultney	do	Eureka Slate Company	do	
14	do	do	Globe Slate Company	do	
15	do	do	Evergreen Slate Company	do	
16	Poultney	Rutland	Lloyd, Owens & Co	Slate	
17	do	do	R. E. Lloyd	do	
18	do	do	Griffith & Nathaniel	do	
19	do	do	Daniel Culver	do	
20	do	do	Williams Brothers & Co	do	
21	Poultney	Rutland	J. Evans & Co	Slate	
22	Pawlet	do	M. Welch	do	
23	do	do	H. J. Williams	do	
24	do	do	E. R. Notton	do	
25	do	do	J. S. Warren	do	
26	Pawlet	Rutland	W. J. Evans	Slate	
27	West Pawlet	do	H. W. Hughes	do	
28	do	do	Rising & Nelson	do	
29	do	do	Owen Evans & Son	do	
30	do	do	The Browned Slate and Flagging Company	do	
31	West Pawlet	Rutland	H. Dillingham	Slate	

CONNECTICUT—CRYSTALLINE SILICEOUS ROCKS.

1	East Killingly	Windham	Joseph Oatley	Gneiss	Hornblende-biotite gneiss
2	Sterling	do	Jeremiah W. Boswell	Granite	Biotite gneiss
3	do	do	Samuel Townsend	do	
4	do	do	Oneco Ledge Company	do	Biotite gneiss
5	Willimantic	do	Alanson Humphrey	Gneiss	
6	Bolton	Tolland	Bolton Quarry Company (S. Beldon & Son)	Mica-schist	Biotite gneiss
7	Glastonbury	Hartford	Chester Hentze	Gneiss	do
8	West Norfolk	Litchfield	Snow & Wooster	do	Biotite-muscovite granite
9	Thomaston	do	Plymouth Granite Company	Gneissoid granite	do
10	Roxbury	do	E. Mower	Granitic gneiss	do
11	Greenwich	Fairfield	John Voorhis	Gneiss	Hornblende-biotite gneiss
12	do	do	Sylvester D. Hill	do	do
13	do	do	William Ritch	do	do
14	do	do	Thomas Ritch	do	do
15	North Bridgeport	do	Wheeler Beers	do	do
16	Ansonia	New Haven	Spring & Wilcox	Gneiss	Muscovite-biotite gneiss
17	New Haven	do	Patrick Dowling	Trap	Diabase
18	do	do	Francis Donnelly	do	do
19	do	do	C. W. Blakeslee	do	do
20	Branford (south of)	do	C. D. Allen (2 quarries)	Granite	Biotite gneiss
21	Leetes island	New Haven	John Beattie	Granite	Biotite granite
22	Stony Creek	do	John Robbins	do	do
23	Haddam	Middlesex	Isaac Arnold	Gneiss	Hornblende-biotite gneiss
24	Middletown	do	Burr & Whitmore	do	do
25	Lyme	New London	C. J. McCurdy and E. E. Salisbury	Red porphyry granite	Biotite granite
26	Lyme (3 miles east of)	New London	Luce & Hoskins	Gray granite	Biotite gneiss
27	Waterford	do	J. B. Palmer & Co	Granite	Biotite granite
28	Niantic (3 miles southeast of)	do	Warren Gates' Sons	do	do
29	Groton	do	Groton Granite Company	do	do
30	do	do	Charles I. Stoll	do	do
31	Groton	New London	Merritt, Gray & Company	Granite	Biotite granite
32	Mason's island	do	F. K. Ballou	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

VERMONT—Marble and Limestone—Continued.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
White and mottled	Fine	Massive	Even, thick	Lower Silurian		1840	16
....do	....do	....do	....do	....do		1850	17
....do	....do	... do	....do	....do		1827	18

VERMONT—Slate.

Blue-black	Fine	Rectangular	Even and smooth	Lower Silurian		1855	1
Purple	....do	Rhomboidal	....do	....do		1865	2
... do	... do	Rhomboidal and rectangular.	....do	....do		1854	3
Purple and green	....do	Rhomboidal	Regular	....do		1852	4
Blue and green	....do	Trapezoidal	... do	... do		1865	5
Purple	Fine	Rectangular	Regular	Lower Silurian		1864	6
Purple and green	....do	Rhomboidal	Even, smooth	....do		1879	7
Variegated	....do	... do	... do	... do		1879	8
Purple, green, and variegated.	....do	....do	... do	... do		1867	9
Variegated, various shades.	... do	Irregular	Even	... do		1852	10
Green and purple, variegated.	Fine	Rhomboidal	Even	Lower Silurian		1876	11
Purple, variegated	....do	do	....do	....do		1876	12
Green	....do	Irregular	....do	....do		1852	13
Green, purple, and variegated.	... do	Rhomboidal and rectangular.	....do	....do		1868	14
Green	....do	Rhomboidal	Irregular	....do		1867	15
Green, purple, and variegated.	Fine	Rhomboidal	Even	Lower Silurian		1868	16
....do	....do	Irregular	.. do	....do		1870	17
Green	....do	....do	....do	....do		1871	18
Sea-green	....do	Variable	....do	....do		1870	19
Green	....do	....do	....do	....do		1879	20
Green	Fine	Variable	Even	Lower Silurian		1874	21
Sea-green	....do	Rhomboidal	....do	....do		1870	22
....do	....do	... do	....do	....do		1878	23
Purple	....do	Variable	... do	....do		1878	24
Sea-green	....do	.. do	....do	....do		1872	25
Sea-green	Fine	Variable	Even	Lower Silurian		1872	26
....do	....do	Rhomboidal	... do	....do		1873	27
... do	....do	Rectangular	.. do	....do		1876	28
....do	... do	Irregular	... do	....do		1876	29
Sea-green and blue-black	....do	Joints parallel	Smooth and fine	.. do		1872	30
Sea-green	Fine	Rectangular	Smooth	Lower Silurian		1878	31

CONNECTICUT—Crystalline Siliceous Rocks.

Light gray	Coarse	Laminated	Irregular, vertical	Archæan		1842	1
Gray and light gray	... do	.. do	... do	.. do		1877	2
... do	....do	.. do	... do	.. do		1875	3
... do	... do	.. do	... do	.. do		1855	4
...	Fine	.. do	Irregular	.. do		1877	5
...	Fine	Laminated	Irregular, nearly vertical	Archæan		1805	6
Dark gray	Coarse	.. do	Irregular sheet and vertical	.. do		1850	7
Light gray	Fine	.. do	... do	... do		1873	8
....do	....do	.. do	Irregular, vertical, and inclined sheet.	.. do		1855	9
... do	...do	.. do	... do	.. do		1873	10
Black	Coarse to fine	Laminated	Irregular sheet and vertical	Archæan		1835	11
....do	... do	.. do	....do	.. do		1830	12
... do	.. do	.. do	... do	... do		1850	13
....do	.. do	.. do	.. do	... do		1850	14
Dark gray	Coarse	.. do	... do	... do		1873	15
Bluish gray	Compact, granular	Laminated	Horizontal sheet and vertical.	Archæan		1848	16
Black	Fine	Massive	Irregular, vertical	Triassic		1870	17
....do	... do	.. do	... do	... do		1871	18
... do	.. do	.. do	... do	... do		1873	19
Dark gray	Coarse	.. do	Much broken	Archæan		1879	20
Gray to red	Coarse, porphyritic	Massive	Irregular sheet and vertical	Archæan		1870	21
... do	... do	.. do	... do	.. do		1878	22
Black	Fine	Laminated	... do	... do		1880	23
... do	Coarse	.. do	Solid	... do		1850	24
Red	Coarse, porphyritic	Massive	Irregular sheet and vertical	.. do		1870	25
Gray	Coarse, striated	Laminated	Irregular sheet and vertical	Archæan		1875	26
Light gray	Fine	Massive	... do	.. do		1885	27
.. do	.. do	.. do	... do	.. do		1879	28
.. do	... do	Indistinctly laminated	... do	... do		1877	29
... do	.. do	... do	... do	... do		1869	30
Light gray	Fine	Indistinctly laminated	Irregular sheet and vertical	Archæan		1840	31
...	Coarse to fine	Massive	Much broken	.. do		1879	32

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

CONNECTICUT—SANDSTONE.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
1	Manchester	Hartford	Charles O. Wolcott	Sandstone	Sandstone
2	East Haven	New Haven	Francis Donelly	do	do
3	do	do	Robert Redfield	do	do
4	Portland	Middlesex	Brainerds & Co	do	do
5	do	do	Middlesex Quarry Company	do	do
6	Portland	Middlesex	Shaler & Hall Quarry Company	Sandstone	Sandstone

NEW YORK—CRYSTALLINE SILICEOUS ROCKS.

1	Hastings-upon-Hudson	Westchester	Munson & Co	Gneiss	Biotite gneiss
2	Cold Spring	Putnam	J. E. Bailey	Granite	Hornblende gneiss
3	Clayton	Jefferson	Robert Forsyth	do	Hornblende granite

NEW YORK—MARBLE AND LIMESTONE.

1	Tuckahoe	Westchester	Tuckahoe Marble Company	Marble	Dolomite
2	do	do	John M. Masterton	do	do
3	Greenport	Columbia	F. W. Jones	Limestone	Limestone
4	Sandy Hill	Washington	Kingsbury Blue Stone Company	do	do
5	Saratoga	Saratoga	Prince Wing	do	Magnesian limestone
6	South Glens Falls	Saratoga	Thomas Reynolds & Co	Limestone	Magnesian limestone
7	Glens Falls	Warren	Glens Falls Company	do	do
8	Crown Point	Essex	Frank Clark	do	do
9	Willsborough	do	Lake Champlain Quarry Company	do	do
10	Plattsburgh	Clinton	Burlington Manufacturing Company	do	
11	Gouverneur	Saint Lawrence	Gouverneur Marble and Whitney Granite Company.	Limestone	Magnesian limestone
12	Three Mile Bay	Jefferson	Oren Fish	do	do
13	Lowville	Lewis	L. H. Carter	do	Limestone
14	Talcottville	do	Melchot Auer	do	
15	Prescott	Oneida	Evan T. Thomas	do	Magnesian limestone
16	Prescott	Oneida	H. & L. N. Jones	Limestone	Magnesian limestone
17	Canajoharie	Montgomery	Charles Shaper	do	do
18	Tylers Hill	do	James Shanahan	do	do
19	do	do	Henry Hurst	do	do
20	do	do	James Shanahan & Co	do	do
21	Amsterdam	Montgomery	James Griswold	Limestone	Magnesian limestone
22	do	do	James Shanahan	do	do
23	do	do	D. C. & N. Hewitt	do	do
24	Sharon Springs	Schoharie	Charles J. Smith	do	do
25	Cobleskill	do	Reilly & Scanlon	do	do
26	Howe's Cave	Schoharie	Howe's Cave Association	Limestone	Magnesian limestone
27	Springfield Centre	Otsego	McCabe Brothers	do	do
28	Onondaga	Onondaga	Hodges & Co	do	do
29	do	do	John Murray	do	do
30	do	do	Patrick McElroy	do	do
31	Fairmount	Onondaga	John Connors	Limestone	Magnesian limestone
32	do	do	M. Dornan	do	do
33	Manlius	do	O. P. Hughes	do	do
34	Auburn	Cayuga	Goodrich & Son	do	do
35	do	do	John Bennett	do	do
36	Auburn	Cayuga	Albert Garret	Limestone	Magnesian limestone
37	Union Springs	do	A. B. Niles	do	do
38	Waterloo	Seneca	Loren Thomas	do	do
39	do	do	John Emmett	do	do
40	Rochester	Monroe	J. B. Pike	do	Dolomite
41	Rochester	Monroe	J. B. Bennett	Limestone	Dolomite
42	do	do	H. S. Brown	do	do
43	Le Roy	Genesee	J. W. Woodruff	do	Magnesian limestone
44	do	do	Wm. S. Brown	do	do
45	Lockport	Niagara	R. & J. Carpenter	do	Calcareous dolomite
46	Williamsville	Erie	J. B. Young	Limestone	Limestone
47	do	do	Lantz & Co	do	do
48	do	do	W. Forlesange	do	do
49	do	do	J. Uebelhoer	do	Magnesian limestone
50	East Buffalo	do	W. W. Bailey	do	do
51	Buffalo	Erie	J. Uebelhoer	Limestone	Magnesian limestone
52	do	do	John Gelsl	do	do
53	do	do	Mrs. J. Gelbtes	do	do
54	do	do	John Ortner	do	do
55	do	do	A. Kaple	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

CONNECTICUT—Sandstone.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Red	Fine	Massive	Irregular	Triassic		1855	1
do	Coarse	do	do	do		1840	2
do	do	do	do	do		1874	3
Brown	Fine	do	do	do		1700	4
do	do	do	do	do		1826	5
Brown	Fine	Massive	Irregular	Triassic		1827	6

NEW YORK—Crystalline Siliceous Rocks.

Light gray	Coarse, porphyritic	Laminated	Few joints	Archæan		1861	1
Gray	Fine	do	Irregular	do		1877	2
Red	Coarse	Massive	Not jointed	do		1876	3

NEW YORK—Marble and Limestone.

White	Fine, crystalline	Massive	Even, thick	Archæan		1860	1
"Water blue"	Medium, crystalline	do	Uneven, thick	do		1825	2
Gray	Semi crystalline, fossiliferous.	do	do	Upper Silurian		1850	3
Dark gray	Fine	do	Even, thick	Lower Silurian		1870	4
Blue-black	Fine, fossiliferous	Irregular	Even, medium thick	do		1860	5
Blue-black	Fine, fossiliferous	Massive	Even, thick	Lower Silurian		1850	6
do	do	do	do	do		1850	7
do	Fine	do	do	do		1876	8
do	Fine, fossiliferous	do	do	do		1875	9
Gray and red	do	do	do	do		1879	10
Gray	Fine, semi-crystalline	Massive	Uneven, thick	Archæan		1876	11
Dark drab	Fine, crystalline	Even, parallel	Even, thin to medium	Lower Silurian		1873	12
Drab	Fine, fossiliferous	Massive	Even, medium to thick	do		1838	13
Dark drab	Fine and coarse	Even, parallel	Even, thin to medium	do		1850	14
Gray	Fine, crystalline	Massive	Even, thick	do		1852	15
Gray	Fine, crystalline	Massive	Even, thick	Lower Silurian		1860	16
Dark drab	Fine and coarse	Indistinct	Even, thin to medium	do		1855	17
Blue-black	Medium, semi-crystalline	Massive	Even, medium	do		1830	18
do	do	do	Even, thick	do		1852	19
do	do	do	do	do		1864	20
Blue-black	Medium, semi-crystalline	Massive	Even, medium to thick	Lower Silurian		1873	21
do	do	do	do	do		1860	22
do	do	do	Even, thin, medium, and thick.	do		1865	23
do	Fine	Indistinct	Even, thin to thick	Upper Silurian		1850	24
Blue and gray	do	Massive	Thin to thick	Devonian		1850	25
Blue-black and gray	Fine	Indistinct	Uneven, thin to thick	Upper Silurian		1866	26
Blue-black	do	Massive	Medium to thick	Devonian		1869	27
Gray	Fine, semi-crystalline	Indistinct	Thick	do		1840	28
do	do	do	do	do		1840	29
do	do	do	do	do		1840	30
Gray	Fine, semi-crystalline	Indistinct	Uneven, medium	Devonian		1830	31
do	do	do	do	do		1830	32
do	do	do	do	do		1870	33
do	Fine, crystalline	Massive	Even, medium	do		1830	34
do	do	do	do	do		1860	35
Gray	Fine, crystalline	Massive	Even, medium	Devonian		1830	36
Blue-black	Fine	do	Even, medium to thick	do		1834	37
Dark gray	do	do	Even, thick	do		1830	38
do	do	do	do	do		1820	39
Dark drab	do	do	Irregular	do		1868	40
Dark drab	Fine	Massive	Irregular	Devonian		1872	41
Blue-black	do	do	Uneven, medium	Upper Silurian		1869	42
Dark gray	Fine, semi-crystalline	do	Even, medium	Devonian		1850	43
do	do	do	do	do		1874	44
Light gray	Medium, semi-crystalline	do	Thick	Upper Silurian		1896	45
Light gray	Medium, semi-crystalline	Massive	Uneven, medium	Devonian		1838	46
do	do	do	do	do		1838	47
do	do	do	do	do		1870	48
do	do	do	Even, medium thick	do		1870	49
Gray	do	do	do	do		1835	50
Light gray	Medium, semi-crystalline	Massive	Even, medium thick	Devonian		1865	51
Gray	do	do	do	do		1859	52
Dark drab	do	do	Even, thick	do		1858	53
do	do	do	do	do		1868	54
do	Fine, semi-crystalline	do	do	do		1820	55

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

NEW YORK—SANDSTONE.

	Location of quarry.	County.	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
1	Potsdam	Saint Lawrence	Potsdam Sandstone Company	Sandstone	Sandstone
2	Hammond	do	James Finnegan	do	do
3	Fort Ann	Washington	Junkans White	do	do
4	Schenectady	Schenectady	Upper Aqueduct Quarry Company	do	do
5	Eminence	Schoharie	Simmonds & Bogardus	Blue-stone	do
6	Hunter's Land	Schoharie	Middleburgh Bluestone Company	Blue-stone	Sandstone
7	Reidsville	Albany	William Stoneburne & Isaac Brate	do	do
8	do	do	Edward Udell	do	do
9	do	do	James B. Winne	do	do
10	Dormansville	do	Allen Kniffen	do	do
11	Leeds	Greene	Leeds Quarries	Blue-stone	Sandstone
12	Kiskatom	do	Jessup & McCarthy	do	do
13	do	do	Moon & Meyer	do	do
14	do	do	James Butler	do	do
15	do	do	Peter Jessup & Co	do	do
16	Kiskatom	Greene	McCabe & Co. and William Dorsey	Blue-stone	Sandstone
17	Palenville	do	Alfred Griffin	do	do
18	do	do	H. B. Walters	do	do
19	Quarryville	Ulster	Peter Daly & Co	do	do
20	do	do	S. O. Haggadon	do	do
21	Quarryville	Ulster	Asa Cook & Co	Blue-stone	Sandstone
22	do	do	Schoonmaker & Cook	do	do
23	do	do	D. Lyman	do	do
24	do	do	Mason & Mack	do	do
25	do	do	John Fawley	do	do
26	Quarryville	Ulster	Mower & Co	Blue-stone	Sandstone
27	do	do	A. Cartwright	do	do
28	do	do	Thomas Fitzpatrick	do	do
29	do	do	Daniel Driscoe	do	do
30	do	do	Michael Maloy	do	do
31	Quarryville	Ulster	Patrick Mermor	Blue-stone	Sandstone
32	do	do	Daniel Driscoe & Co	do	do
33	do	do	Cunningham Brothers	do	do
34	do	do	Francis Stone	do	do
35	do	do	W. Teetsel & Co	do	do
36	Quarryville	Ulster	Adam Sax	Blue-stone	Sandstone
37	do	do	Corcoran & Kelley	do	do
38	do	do	Patrick Devery & Co	do	do
39	do	do	Michael Kelley	do	do
40	Saugerties	do	John Hackett	do	do
41	Saugerties	Ulster	Thomas Maher	Blue-stone	Sandstone
42	do	do	Thomas Rafferty	do	do
43	do	do	Pat Moore & Co	do	do
44	do	do	Bethuns & Brainard	do	do
45	do	do	Margaret Pierce	do	do
46	Saugerties	Ulster	John Dorgan	Blue-stone	Sandstone
47	do	do	John Lanagan	do	do
48	do	do	Thomas Malone	do	do
49	do	do	Scott Brothers	do	do
50	Kingston	do	William Hart	do	do
51	Kingston	Ulster	Phillip Stauble	Blue-stone	Sandstone
52	do	do	Jno H. Carle & Co	do	do
53	do	do	Mean, Goldbaugh, Kull & Saan	do	do
54	do	do	R. Short & Co., H. Brink & Co., and others	do	do
55	do	do	Barney Burns	do	do
56	Kingston	Ulster	McDonald & Co., Riley & Co., and others	Blue-stone	Sandstone
57	do	do	Frank Young	do	do
58	do	do	Carle & Van Hautenburgh	do	do
59	do	do	Patrick Maguire	do	do
60	do	do	Burke & Co	do	do
61	Kingston	Ulster	Christopher Maguire	Blue-stone	Sandstone
62	do	do	Leahy & Co	do	do
63	do	do	David Henderson	do	do
64	do	do	Osterhout & Sheehan	do	do
65	do	do	Robert & Robert J. Charlton	do	do
66	Kingston	Ulster	William Charlton	Blue-stone	Sandstone
67	do	do	Michael Coogan	do	do
68	do	do	Welsh & Hays	do	do
69	do	do	David Murphy	do	do
70	do	do	James Leahy	do	do
71	Kingston	Ulster	B. Leahy	Blue-stone	Sandstone
72	do	do	James Ryan	do	do
73	do	do	Ryan & Co	do	do
74	do	do	McCourt Brothers	do	do
75	do	do	William Donaldson	do	do
76	Kingston	Ulster	Morrissey Brothers	Blue-stone	Sandstone
77	do	do	Patrick Conlon	do	do
78	do	do	James L. Burke	do	do
79	do	do	Michael Lamb	do	do
80	do	do	Michael H. Fisher	do	do
81	Kingston	Ulster	James Highland, P. Urel	Blue-stone	Sandstone
82	do	do	James Haggerty	do	do
83	West Hurley	do	Thomas Conlon	do	do
84	do	do	Thomas Grant	do	do
85	do	do	Patrick Bahan	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

NEW YORK—SANDSTONE.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Red	Coarse	Even, parallel	Even, thin to medium	Lower Silurian		1856	1
do	do	Indistinct	Even, thin to thick	do		1876	2
Light gray	Medium to fine	Massive	Uneven, medium	do		1849	3
Blue black	Fine	do	Uneven, thick	do		1867	4
Dark gray	Fine and coarse	Even, parallel	Even, thin	Devonian		1879	5
Dark gray	Coarse	Even, parallel	Variable	Devonian		1865	6
do	do	do	Even, thin	do		1850	7
do	do	do	do	do		1860	8
do	do	do	do	do		1850	9
do	do	do	do	do		1870	10
Dark gray	Fine and coarse	Even, parallel	Even, thin	Devonian		1840	11
do	do	do	do	do		1873	12
do	Medium	do	Even, thin to medium	do		1860	13
do	do	do	do	do		1850	14
do	Fine	do	do	do		1860	15
Dark gray	Fine	Even, parallel	Even, thin to thick	Devonian		1873	16
do	do	Indistinct	Even, thin to medium	do		1855	17
do	do	do	do	do		1850	18
do	do	Even, parallel	Even, thin to thick	do		1860	19
do	do	do	do	do		1845	20
Dark gray	Fine	Indistinct	Even, thin to thick	Devonian		1850	21
do	do	Even, parallel	do	do		1860	22
do	do	do	do	do		1854	23
do	do	Indistinct	Even, thin to medium	do		1850	24
do	do	do	do	do		1860	25
Dark gray	Fine	Indistinct	Even, thin to thick	Devonian		1850	26
do	do	do	do	do		1845	27
do	do	do	do	do		1845	28
do	do	do	do	do		1845	29
do	do	do	do	do		1845	30
Dark gray	Fine	Indistinct	Even, thin to thick	Devonian		1840	31
do	do	do	do	do		1850	32
do	do	do	do	do		1840	33
do	do	do	do	do		1862	34
do	do	Even, parallel	do	do		1855	35
Dark gray	Fine	Even, parallel	Even, thin to thick	Devonian		1845	36
do	do	do	do	do		1845	37
do	do	do	Even, thin to medium	do		1850	38
do	Coarse	do	Even, thin to thick	do		1877	39
do	do	Indistinct	do	do		1850	40
Dark gray	Fine	Indistinct	Even, thin to thick	Devonian		1845	41
do	do	do	do	do		1850	42
do	do	do	do	do		1870	43
do	do	do	do	do		1860	44
do	do	do	do	do		1845	45
Dark gray	Fine	Indistinct	Even, thin to thick	Devonian		1850	46
do	do	do	do	do		1845	47
do	do	do	do	do		1850	48
do	do	do	do	do		1845	49
do	do	Even, parallel	do	do		1860	50
Dark gray	Fine	Even, parallel	Even, thin to thick	Devonian		1850	51
do	do	do	do	do		1845	52
do	do	Indistinct	do	do		1850	53
do	do	Even, parallel	do	do		1861	54
do	do	Indistinct	do	do		1850	55
Dark gray	Fine	Even, parallel	Even, thin to thick	Devonian		1865	56
do	do	do	do	do		1860	57
do	do	do	do	do		1842	58
do	do	do	do	do		1840	59
do	do	do	do	do		1858	60
Dark gray	Fine	Even, parallel	Even, thin to thick	Devonian		1845	61
do	do	do	do	do		1850	62
Gray	do	do	do	do		1860	63
Dark gray	do	do	Even, thin to medium	do		1864	64
do	do	do	Even, thin to thick	do		1850	65
Dark gray	Fine	Even, parallel	Even, thin to thick	Devonian		1850	66
do	do	do	do	do		1860	67
do	do	do	do	do		1850	68
do	do	do	do	do		1871	69
do	do	do	do	do		1871	70
Dark gray	Fine	Even, parallel	Even, thin to thick	Devonian		1850	71
do	do	do	do	do		1868	72
do	do	do	do	do		1871	73
do	do	do	Even, thin to medium	do		1859	74
do	do	do	Even, thin to thick	do		1869	75
Dark gray	Fine	Even, parallel	Even, thin to medium	Devonian		1870	76
do	do	do	do	do		1840	77
Bluish gray	do	do	do	do		1850	78
Dark gray	do	do	do	do		1847	79
do	do	do	do	do		1840	80
Dark gray	Fine	Even, parallel	Even, thin to medium	Devonian		1847	81
do	do	do	do	do		1850	82
do	do	do	do	do		1860	83
do	do	do	do	do		1850	84
do	do	do	do	do		1860	85

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

NEW YORK—SANDSTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
86	West Hurley	Ulster	John Dorn	Blue-stone	Sandstone
87	do	do	Theodore Diesel	do	do
88	do	do	Diprose, Lawrence & Pearce	do	do
89	do	do	Patrick O'Neil	do	do
90	do	do	William H. Studer	do	do
91	West Hurley	Ulster	La Fever & Co	Blue-stone	Sandstone
92	do	do	Gladden Wolven	do	do
93	do	do	[illegible]	do	do
94	do	do	William L. Sweet	do	do
95	do	do	Barnes Sawdy	do	do
96	West Hurley	Ulster	Joseph Snyder	Blue-stone	Sandstone
97	do	do	Michael Bach and Michael Bach	do	do
98	do	do	Purcell & Dodd and P. Finnegan	do	do
99	do	do	Patrick Rooney and others	do	do
100	do	do	Rondout Quarry	do	do
101	West Saugerties	Ulster	Theo Studer	Blue-stone	Sandstone
102	do	do	Edward Bach	do	do
103	do	do	Vernon Bach	do	do
104	High Woods	do	W. Swart & Co	do	do
105	do	do	Van Aken & Co	do	do
106	High Woods	Ulster	Nathan Van Aken	Blue-stone	Sandstone
107	do	do	James Van Aken	do	do
108	do	do	Cooke & Co	do	do
109	do	do	Cooper & Co	do	do
110	Woodstock	do	Philip H. Lupo	do	do
111	Woodstock	Ulster	Pitts & Maxwell	Blue-stone	Sandstone
112	do	do	Lawson & Finch	do	do
113	do	do	Noah Welden	do	do
114	do	do	Michael Boglin	do	do
115	do	do	Thomas Mead, John Gable	do	do
116	Woodstock	Ulster	Thomas Hennessy	Blue-stone	Sandstone
117	do	do	Henry Russell & Co	do	do
118	Shandaken	do	J. H. Risley	do	do
119	do	do	do	Sandstone	do
120	Phœnicia	do	J. L. McGrath	Blue-stone	do
121	Phœnicia	Ulster	Jamieson Brothers	Blue-stone	Sandstone
122	do	do	George Wilson	do	do
123	do	do	Thomas Rider	do	do
124	do	do	Delamater & Rosie	do	do
125	do	do	Mellen & Delamater	do	do
126	Phœnicia	Ulster	J. McGrath	Blue-stone	Sandstone
127	Bloomville	do	James Smethurst	do	do
128	do	do	Lane & Co	do	do
129	do	do	Frank A. Avery	do	do
130	Brodhead	do	James H. Snow	do	do
131	Brodhead	Ulster	Cornish & Rowe	Blue-stone	Sandstone
132	do	do	J. B. Hammond	do	do
133	do	do	P. W. Peck Block	do	do
134	do	do	A. Bigham & Co	do	do
135	do	do	Hungerford & Boice	do	do
136	Ellenville	Ulster	Rochester and Wawarsing Quarries	Blue-stone	Sandstone
137	[illegible] south of Poughkeepsie	do	Nathan Dubois	do	do
138	Newel	Dutchess	Nelson Pratt	Bluestone	do
139	Pine Plain	Nelson	Whalen, Martin & Van Alen	Blue-stone	do
140	[illegible] west of West Brooksville	do	West Brooks Bluestones	do	do
141	Rockland	Delaware	Patrick Pettit and others	Blue-stone	Sandstone
142	Tompkinsville	do	John Rhodes	do	do
143	do	do	Patrick Riley	do	do
144	do	do	George Weatherhead	do	do
145	Margaretville	do	Grant Burgess	do	do
146	Roxbury	Delaware	B. F. Peterson	Blue-stone	Sandstone
147	do	do	Loucks & Scott	do	do
148	Grand Gorge	do	Sanford Crandall and Andrew Lillie	do	do
149	Cooperstown	Otsego	John Wood	Sandstone	do
150	Onconta	do	D. Ott	Blue-stone	do
151	Guilford	Chenango	Mrs. W. W. Davis	Blue-stone	Sandstone
152	Smithville Flats	do	John Mead	do	do
153	Southampton New Hartford	Oneida	Mahon & Gilreath	Sandstone	do
154	Camden	do	Nelson Payne	do	do
155	Atwater	Cayuga	J. G. Baeger	Blue-stone	do
156	Ithaca	Tompkins	McClune's Quarry	Blue-stone	Sandstone
157	Trumansburg	do	Dumont & Cusic	Blue-stone	do
158	Cayuga	Seneca	T. H. Kinney	do	Sandstone (calcareous)
159	do	do	C. O. Cogan	do	do
160	Watkins Glen	Schuyler	Northern Central Railway Company	Sandstone	Sandstone
161	Corning	Steuben	John Kelley	Sandstone	Sandstone (calcareous)
162	do	do	George Barnard	do	do
163	do	do	L. Field	do	do
164	Canisteo	do	James Mullen	do	do
165	Brockport	Monroe	Hugh Quinn	do	Sandstone
166	Brockport	Monroe	George Coon	Sandstone	Sandstone
167	Hulberton	Orleans	O'Brien & O'Reilly	do	do
168	do	do	A. J. Squires	do	do
169	Albion	do	Gilbert Brady	do	do
170	do	do	Albion and Medina Sandstone Company	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

NEW YORK—SANDSTONE—Continued.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Dark gray	Fine	Even, parallel	Even, thin to medium	Devonian		1874	86
do	Coarse	do	do	do		1877	87
do	Fine	do	do	do		1865	88
do	do	do	Even, thin to thick	do		1864	89
do	do	do	Even, thin to medium	do		1860	90
Dark gray	Fine	Even, parallel	Even, thin to medium	Devonian		1860	91
do	do	do	do	do		1879	92
do	do	do	do	do		1845	93
do	do	do	do	do		1878	94
do	do	do	Medium to thick	do		1855	95
Dark gray	Fine	Even, parallel	Even, thin to medium	Devonian		1840	96
do	do	do	do	do		1859	97
do	do	do	do	do		1875	98
do	do	do	do	do		1840	99
do	do	do	do	do		1856	100
Dark gray	Fine	Indistinct	Even, thin to medium	Devonian		1850	101
do	do	do	do	do		1857	102
do	do	do	Even, thick	do		1850	103
do	do	do	Even, thin to thick	do		1860	104
do	do	do	do	do		1860	105
Dark gray	Fine	Indistinct	Even, thin to thick	Devonian		1860	106
do	do	do	do	do		1871	107
do	Coarse	do	do	do		1860	108
do	do	do	do	do		1860	109
do	Fine	do	Uneven, thin to thick	do		1875	110
Dark gray	Fine	Indistinct	Even, thick	Devonian		1869	111
do	do	do	do	do		1870	112
do	Coarse	do	do	do		1860	113
do	Fine	do	Even, thin to medium	do		1878	114
do	Coarse	do	Even, medium to thick	do		1850	115
Dark gray	Coarse	Indistinct	Even, medium to thick	Devonian		1850	116
do	do	do	do	do		1850	117
do	do	Even, parallel	Even, thin to medium	do		1872	118
do	do	do	do	do		1874	119
do	do	do	do	do		1871	120
Dark gray	Coarse	Massive	Even, thin to medium	Devonian		1876	121
do	do	do	do	do		1873	122
do	Fine	do	do	do		1875	123
do	do	do	do	do		1878	124
Reddish brown	do	do	Even, medium to thick	do		1879	125
Dark drab	Fine	Massive	Medium to thick	Devonian		1869	126
Dark gray	do	do	Even, thick	do		1877	127
do	do	do	do	do		1877	128
do	do	do	do	do		1877	129
do	do	do	do	do		1870	130
Blue-black	Coarse	Indistinct	Even, thick	Devonian		1878	131
Dark gray	Fine	do	do	do		1871	132
do	do	do	do	do		1871	133
do	do	do	do	do		1877	134
do	do	Massive	do	do		1877	135
Dark gray	Coarse	Even, parallel	Thin to medium	Devonian		1871	136
do	do	Variable	Even, thick	Lower Silurian		1870	137
Red	Fine	Massive	Even, medium to thick	Triassic			138
Gray	do	Even, parallel	Even, thin to medium	Devonian		1870	139
Dark gray	Coarse	do	Even, thin to thick	do		1850	140
Gray	Coarse	Even, parallel	Even, thin to thick	Devonian		1880	141
Dark gray	do	Indistinct	do	do		1880	142
do	do	do	do	do		1879	143
do	do	do	do	do		1879	144
do	Fine	do	Even, thin to medium	do	Catskill	1879	145
Grayish brown	Coarse	Indistinct	Even, thin to medium	Devonian	Catskill	1860	146
do	do	do	do	do	do	1871	147
Gray	Medium	do	do	do	do	1871	148
Dark gray	Fine	do	Even, thick	do	Hamilton	1862	149
do	do	do	Even, thin to medium	do	Chemung	1879	150
Dark gray	Fine	Massive	Even, thin to medium	Devonian	Chemung	1850	151
do	do	Indistinct	Even, medium to thick	do	do	1871	152
Light gray	Coarse	Massive	Uneven, medium to thick	Upper Silurian	Oneida	1860	153
do	do	Indistinct	Even, thin to medium	do	Medina	1860	154
Dark gray	Fine	Even, parallel	do	Devonian	Portage	1878	155
Dark gray	Fine	Even, parallel	Even, thin to medium	Devonian	Portage	1850	156
do	do	Massive	do	do	Chemung	1854	157
do	do	Even, parallel	Even, medium	do	do	1850	158
do	do	do	do	do	do	1849	159
do	do	Massive	Even, medium to thick	do	do	1878	160
Dark drab	Fine	Massive	Uneven, thin to thick	Devonian	Chemung	1871	161
do	do	do	do	do	do	1871	162
do	do	do	do	do	do	1860	163
Light blue	do	do	Even, medium	do	do	1871	164
Light gray	do	do	Uneven, thin to medium	Upper Silurian	Medina	1870	165
Light gray	Fine	Massive	Uneven, thin to medium	Upper Silurian	Medina	1876	166
Red	do	Indistinct	Uneven, thick	do	do	1873	167
do	Coarse	do	do	do	do	1869	168
do	Fine	do	Even, medium	do	do	1860	169
Light gray	do	Massive	Even, thick	do	do	1860	170

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

NEW YORK—SANDSTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
171	Medina	Orleans	Kearney, Barrett & Co.	Sandstone	Sandstone
172	do	do	Isaac Holloway	do	do
173	do	do	Patrick Horan	do	do
174	do	do	A. J. McCormick	do	do
175	Lockport	Niagara	Charles Whitmore	do	do
176	Warsaw	Wyoming	Morris & Son	Flagstone	Sandstone (calcareous)
177	do	do	Philander Twesdell	do	do
178	Castile	do	George Sutherland	Sandstone	Sandstone
179	Belfast	Allegany	John Lang	do	do
180	Jamestown	Chautauqua	John McVeigh	do	do
181	Jamestown	Chautauqua	J. O'Brien	Sandstone	do

NEW YORK—SLATE.

1	Hampton	Washington	New England Slate Company	Slate	
2	do	do	Boston and New York Slate Company	do	
3	do	do	David Williams & Brothers	do	
4	do	do	Lemuel J. Warren	do	
5	do	do	do	do	
6	Middle Granville	Washington	Penrhyn Slate Company	Slate	
7	do	do	Albany Slate Company	do	
8	do	do	Middle Granville Slate Company	do	
9	Granville	do	Empire Slate Company	do	
10	do	do	Mettowee Red Slate Company	do	
11	Granville	Washington	North Bend Slate Company	Slate	
12	Salem	do	Salem Slate Company	do	

NEW JERSEY—CRYSTALLINE SILICEOUS ROCKS.

1	Bergen Hill	Hudson	Bergen Hill	Trap rock	Diabase
2	Dover	Morris	Delaware, Lackawanna and Western Railroad Company.	Gneiss	Gneiss

NEW JERSEY—SANDSTONE.

1	Flagstone Hill, Wantage township	Sussex	Asa & George Carr	Graywacke	
2	Southern outskirts of Paterson	Passaic	William P. Hartley	Sandstone	
3	Belleville, Avondale post-office	Essex	A. Philip & Son	do	
4	do	do	William A. Joyce	do	
5	do	do	J. B. I. Robinson	do	
6	Pleasant Valley, West Orange	Essex	F. W. Shramp	Sandstone	
7	Orange Mountain	do	James Bell & Co	do	
8	Newark	do	Newark Quarry Company	do	
9	do	do	Kocher Bros	do	
10	do	do	Philip Hochule	do	
11	Martinsville	Somerset	William E. Bartle & Bro	Sandstone	
12	Milford, Belvidere and Delaware Railroad	Hunterdon	Smith Clark	do	
13	1 mile northwest of Prallsville	do	Pennsylvania Railroad Company	do	
14	Stockton	do	James Talley	do	
15	do	do	Peter Post	do	
16	Princeton	Mercer	Thomas Jewell	Sandstone	
17	Greensburg	do	L. Clark & Bro	do	
18	do	do	Chas. Keeler & Son	do	
19	do	do	Greensburg Granite and Freestone Company.	do	
20	Egg Harbor City	Atlantic	Wolfsheffer Bros	do	

NEW JERSEY—SLATE.

1	Princeton	Mercer	Stephen Margerum	Sandstone (slate)	
2	La Fayette	Sussex	Williams & Titus	Slate	
3	do	do	Thos. Jones	do	

PENNSYLVANIA—CRYSTALLINE SILICEOUS ROCKS.

1	Twenty-third ward, Philadelphia	Philadelphia	Barbour & Ireland and S. France	Gneiss	Biotite granite
2	do	do	House of Correction, Employment, and Reformation.	Syenite	
3	Twenty-first ward, Philadelphia	do	McKinney	Gneiss	Hornblende gneiss
4	Twenty-second ward, Philadelphia	do	John Nolan	do	Muscovite gneiss
5	do	do	Nester & Shehane	do	Hornblende gneiss
6	Jenkintown	Montgomery	James Conn	Gneiss	Hornblende gneiss
7	Jenkintown and Mill Creek	do	Eldridge & Stewart (2 quarries)	do	do
8	Chester	Delaware	A. O. & J. O. Deshong, jr.	do	Biotite-muscovite gneiss
9	do	do	George G. Leiper	do	do
10	do	do	H. L. Powell	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

NEW YORK—Sandstone—Continued.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Pinkish gray	Fine	Massive	Even, thick	Upper Silurian	Medina	1840	171
Light gray	do	do	Even, medium	do	do	1851	172
Red	do	Indistinct	do	do	do	1845	173
Red and gray	do	do	do	do	do	1872	174
Light gray	do	Massive	do	do	do	1825	175
Gray	Fine	Massive	Even, medium	Devonian	Portage	1876	176
do	do	do	do	do	do	1876	177
do	do	do	Even, medium to thick	do	do	1874	178
Dark drab	do	do	Even, thick	do	Chemung	1876	179
Gray	do	do	Even, medium	do	do	1849	180
Gray	Fine	Massive	Even, medium	Devonian	Chemung	1840	181

NEW YORK—Slate.

Purple	Fine	Rhomboidal	Even	Lower Silurian	Cambrian	1870	1
Red	do	do	do	do	do	1840	2
Green and purple	do	do	do	do	do	1873	3
do	do	Rhomboidal, irregular	do	do	do	1876	4
Red	do	do	do	do	do	1880	5
Purple and green, variegated.	Fine	Prismatic, quadrangular	Even	Lower Silurian	Cambrian	1850	6
do	do	do	do	do	Potsdam	1869	7
do	do	do	do	do	do	1852	8
Variegated and purple	do	Rhomboidal	Uneven	do	Cambrian	1873	9
Red	do	do	Even	do	Potsdam	1877	10
Red	Fine	Rhomboidal	Even	Lower Silurian	Potsdam	1872	11
Purple variegated, green	do	do	do	do	Cambrian	1868	12

NEW JERSEY—Crystalline Siliceous Rocks.

Dark gray	Variable	Massive	Irregular	Triassic			1
Gray	Medium		Thick	Archæan		1869	2

NEW JERSEY—Sandstone.

Gray	Fine	Variable	Even, thin to thick	Lower Silurian		1859	1
Grayish brown	Medium	Massive	Thin to thick	Triassic		1845	2
do	do	Indistinct	Thick	do		1775	3
do	do	do	do	do		1854	4
do	do	do	do	do		1860	5
Grayish brown	Fine	Variable	Thick	Triassic		1871	6
do	Coarse	Massive	do	do		1880	7
do	Medium	Indistinct	do	do		1842	8
do	do	do	do	do		1875	9
do	do	Irregular	do	do		1808	10
Dark gray	Fine	Massive	Thick	Triassic		1857	11
do	do	Even, parallel	Thin	do		1859	12
Grayish brown	Coarse, conglomerate	Massive	Thick	do		1850	13
do	Coarse	do	do	do		1876	14
do	do	do	do	do		1876	15
Gray	Medium	Irregular	Thick	Triassic		1800	16
Grayish brown	do	Massive	do	do		1843	17
do	Coarse	do	do	do		1833	18
do	Medium		do	do		1843	19
Brown	Coarse, conglomerate	Irregular	do	Cretaceous		1873	20

NEW JERSEY—Slate.

	Fine			Triassic		1843	1
Blue-black	do			Lower Silurian	Hudson River slate	1844	2
do	do			do			3

PENNSYLVANIA—Crystalline Siliceous Rocks.

Dark gray	Fine	Indistinct	Horizontal sheet and vertical.	Archæan		1850	1
Gray	Coarse and fine	Laminated	do	do		1874	2
Dark gray	Fine	do	do	do		1857	3
Gray	Coarse	do	Irregular	do		1750	4
Dark gray	Fine	do	Horizontal and vertical	do		1860	5
Gray	Coarse and fine	Laminated	Irregular	Archæan		1858	6
do	do	do	do	do		1860 / 1875	7
do	Fine	do	do	do		1860	8
do	Medium	do	Horizontal and vertical	do		1750	9
do	do	do	Irregular	do		1860	10

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

PENNSYLVANIA—CRYSTALLINE SILICEOUS ROCKS—Continued.

	Location of quarry	County	Name of the corporation, company, or individual	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
11	2½ miles east by northeast from Chester	Delaware	Joseph H. Ward	Gneiss	Biotite gneiss
12	2½ miles north from Chester	do	[illegible] & Lewis	do	Muscovite-biotite gneiss
13	Colliss station on Diamond post office	Lancaster	John Keller	Granite	Diabase
14	Hicks	York	Northern Central Railway Company	Conewago granite	do
15	1 mile south of Gettysburg	Adams	D. F. Fahnestock	Granite	do

PENNSYLVANIA—MARBLE AND LIMESTONE.

1	Easton	Northampton	George & Isaac A. Smith	Limestone	Dolomite
2	Williams Point	Northampton	I. C. Coil	Marble and limestone	Limestone
3	Lower Cumberland	do	Pen Argyl Cumberland Stone Company	Limestone	Magnesian limestone
4	Wind Gap Switch	do	Cornwall & New Oxford Railroad Company	do	do
5	Bridgeport	do	Pennsylvania Marble Company	Marble	Limestone
6	Road to Pine Grove station	Montgomery	I. J. Deer	Marble	Limestone
7	Flourtown Switch	do	Daniel O. Heinert	do	do
8	[illegible] Switch	Chester	Mason Perry	Limestone	Calcareous dolomite
9	Lapidum	Harford	Philadelphia, Wilmington & Baltimore Railroad Co	do	do
10	Kenning	do	Wm. B. Smith	do	do
11	Reading	Berks	John H. Sternberg	Limestone	Calcareous dolomite
12	Mount Aetna	Lebanon	Jacob W. Bomberger	do	Limestone
13	Hamburg, Schuylkill county, road to	Berks	Commercial Company	do	Magnesian limestone
14	Leaman Place	Lancaster	H. H. Witmer (James Young, lessee)	do	Calcareous dolomite
15	Lancaster	do	John W. Myers	do	Dolomite
16	Lancaster	Lancaster	Wright & Wortman	Limestone	Dolomite
17	York	York	C. F. Small	do	Calcareous dolomite
18	Harrisburg	Cumberland	McCormick & Co.	do	Dolomite
19	do	do	[illegible]	do	do
20	Shiremanstown (3 miles south of)	do	Moser & Sidle	do	Calcareous-dolomitic limestone
21	Carlisle	Cumberland	W. F. Noble	Limestone	Calcareous dolomite
22	Columbia	Lancaster	Henry Hipple	do	do
23	Connellsville (3 miles southeast of)	Fayette	A. R. Banning	Limestone	Limestone

PENNSYLVANIA—SANDSTONE.

1	Bethlehem	Berks	Thomas H. Estaugh	Sandstone	
2	Norristown	do	Shaw & Wentzel	do	
3	Norristown	do	Bertolet & Lukens	do	
4	Norristown	Montgomery	[illegible] Lukens	do	
5	Richboro	do	J. H. Dyer	do	
6	Mohns Store	Berks	Dapples & Jacobs	Sandstone	
7	Hummelstown Brown Stone station (3 miles south of)	Dauphin	Hummelstown Brown Stone Company	do	
8	Conestoga	Lancaster	Henry L. Weeks	do	Argillaceous schist
9	Bridgeport	Berks	Dapples & Jacobs	do	
10	West Spring	Clinton	Henry Gerst	Sandstone	Sandstone (bituminous)
11	Pond Bank	Pike	C. W. Mumford & Co.	Blue stone	
12	Scranton (3 miles north of)	Lackawanna	John [illegible]	Sandstone	
13	do	do	do	do	
14	Laurel Run Station	Luzerne	Pennsylvania	do	
15	Sugar Notch	do	Delaware, Lackawanna, and Western R. R.	do	
16	Jacksonburg	Lawrence	George Neal	Sandstone	
17	Harrison	Mercer	C. C. Ranch, agent	do	
18	Sandy Lake	Mercer	Pine Tree Stone Co.	do	
19	do	do	do	Flag stone	
20	Black Walnut	do	Wyoming Stone Company	Sandstone	
21	Salem's Bridge	Wyoming	A. R. Fordyce & Co.	Sandstone	
22	do	do	Brobst & Schopp	do	
23	Nanticoke	do	Myers, Shields & Son	do	
24	Bryant	Susquehanna	Erie Railroad Company	Flag stone	
25	do	do	Joseph Botts	do	
26	Bryant	Susquehanna	Mc[illegible] & Co.	Flag stone	
27	Mansfield	Tioga	Mansfield Flagging Company	Sandstone	
28	Antrim	do	Pollock & Gaffney	do	
29	Farrandsville	Clinton	E. F. Hawk & Co.	do	
30	do	do	Jno. McNally	do	
31	McVeytown	Mifflin	Joseph Watson	Sandstone	
32	Juniata Narrows	Huntingdon	Irvin Brothers	do	
33	Alexandria	Huntingdon	William Myers	do	
34	Alexandria (3 miles from)	do	Booth & Mayer	do	
35	Saltillo	Somerset	John McAdams	Flag stone	
36	Johnstown	Cambria	Cambria Iron Company	Molassas sandstone	
37	do	do	Gore & Lockwood	Sandstone	
38	Luzerne	Jefferson	Allegheny Valley Railroad Company	do	
39	Freeport	Armstrong	David Taylor	do	
40	Lucesco	Westmoreland	John A. Huffman	do	
41	Derry	Westmoreland	Loyalhanna Coal and Coke Company	Sandstone	
42	do	do	John C. Campbell	do	
43	Greensburg	do	S. Zimmerman	do	
44	Webster	do	William Nelson	Flag-stone	
45	Scottdale	do	Samuel Dunmire	do	

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

PENNSYLVANIA—Crystalline Siliceous Rocks—Continued.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Gray	Fine	Laminated	Horizontal sheet	Archæan		1880	11
do	Coarse	do	Few joints	do		1770	12
Dark gray	Fine	Massive	Irregular	Triassic		1868	13
Gray	Coarse	do	do	do		1861	14
do	do	do	Bowlders	Archæan		1840	15

PENNSYLVANIA—Marble and Limestone.

Blue	Fine	Massive	Even, medium to thick	Lower Silurian		1870	1
Light blue	Coarse, fine, crystalline	Irregular	do	do		1756	2
Gray	Medium, crystalline	do	Uneven, thin to thick	do		1849	3
do	do	do	Uneven, medium to thick	do		1840	4
Light blue	Fine, crystalline	do	Even, medium to thick	do		1800	5
Blue	Fine, crystalline	Irregular	Uneven, thick	Lower Silurian		1825	6
do	do	do	Uneven, medium to thick	do		1856	7
do	Fine	do	Even, thick	do		1841	8
Gray	do	Massive	do	do		1849	9
Blue	do	Indistinct	Even, thin to thick	do		1830	10
Blue	Fine	Indistinct	Even, thin to thick	Lower Silurian		1881	11
Blue-black	Fine, crystalline	Irregular	Even, medium to thick	do		1866	12
Blue	Fine	do	Even, thin to thick	do		1856	13
Dark gray	do	Indistinct	Even, medium to thick	do		1869	14
Blue-black	do	do	Even, thin to thick	do		1840	15
Blue-black	Fine	Indistinct	Even, thin to thick	Lower Silurian		1840	16
Black	Fine, porphyritic	Massive	Even, medium to thick	do		1840	17
Dark drab	Fine	Even, parallel	Uneven, medium to thick	do		1849	18
do	do	do	do	do		1879	19
Blue	do	do	Even, thin to thick	do		1850	20
Blue-black	Fine	Indistinct	Even, thin to thick	Lower Silurian		1878	21
do	do	Massive	do	do		1812	22
Drab	Fine, crystalline, and compact.	Even parallel	Even, thick	Sub-Carboniferous	Umbral	1875	23

PENNSYLVANIA—Sandstone.

Brown	Medium	Indistinct	Even, thick	Triassic		1874	1
do	Coarse	do	do	do		1840	2
do	do	Even	do	do		1856	3
do	do	Indistinct	Even, medium to thick	do		1878	4
do	do	do	Even, thick	do		1868	5
Brown	Medium	Massive	Even, thick	Triassic		1780	6
do	do	do	do	do		1867	7
do	Fine	do	do	Lower Silurian		1845	8
Gray	do	Massive	Even, thick	do		1850	9
Dark gray	do	Even, parallel	Even, thin	Devonian		1878	10
Dark gray	Fine	Massive	Even, thin to medium	Devonian		1865	11
do	Medium	do	Even, thin to thick	Sub-Carboniferous		1864	12
Buff	do	Indistinct	Even, thin to medium	Devonian		1869	13
Red	do	Even, parallel	do	do		1850	14
Dark gray	do	do	Even, thick	Carboniferous		1840	15
Gray	Coarse	Even, parallel	Even, medium to thick	Carboniferous		1835	16
Dark gray	Fine	Massive	do	Upper Silurian		1830	17
do	do	do	Even, parallel, thick	Devonian		1867	18
do	do	do	Even, thin to medium	do		1876	19
do	do	do	Even, thin to thick	do		1860	20
Dark gray	Fine	Massive	Even, thin to thick	Devonian		1870	21
do	do	do	do	do		1866	22
do	do	do	do	do		1870	23
do	do	do	Even, thin to medium	do		1878	24
do	do	do	do	do		1878	25
Dark gray	Fine	Massive	Even, thin to medium	Devonian		1878	26
do	do	Vesicular	Even, thick	do		1871	27
Light gray	Coarse	Massive	Even, thick	Carboniferous		1872	28
Buff	Medium	do	Even, thin to thick	Devonian		1866	29
Dark gray and brown	Fine	Indistinct	Even, thin to thick	do		1830	30
Gray	Coarse	Even, parallel	Even, thin to thick	Devonian		1880	31
Light gray	Medium	Even, parallel	Even, thick	Upper Silurian		1868	32
Gray	do	Even, parallel	Even, thin to thick	Sub-Carboniferous		1880	33
do	do	Irregular	Even, thick	Devonian		1840	34
do	do	do	Even, medium to thick	Carboniferous		1880	35
Dark gray	Medium	Massive	Even, medium to thick	Carboniferous		1865	36
Gray	Coarse	Indistinct	Uneven, medium to thick	do		1867	37
do	do	Massive	Even, thick	do		1872	38
Gray and light brown	do	Irregular	Uneven, medium	do		1865	39
Gray	do	do	Even, thin to thick	do		1870	40
Gray	Medium	Massive	Even, thin to thick	Carboniferous		1850	41
Reddish gray	Coarse	Indistinct	Bowlders	do		1840	42
Gray	Medium	Irregular	Uneven, thin to medium	do		1861	43
do	Fine	Even, parallel	Even, thin to medium	do		1850	44
Brown	Medium	Irregular	Even, thin	do		1876	45

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

PENNSYLVANIA—SANDSTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
46	Connellsville	Fayette	Christian Slabley	Sandstone	Sandstone
47	Uniontown (3 miles southeast of)	do	James Frazer	do	do
48	Uniontown (4 miles southeast of)	do	D. Shapley	do	do
49	Waynesburgh	Greene	Simeon Rinehart	do	do
50	West Union	do	John Lapham	do	do
51	Washington (3 miles west of)	Washington	D. Haggerty	Sandstone	Sandstone
52	Washington (3 miles east of)	do	Hallam Bros	do	do
53	Washington	do	John Brady	do	do
54	Canonsburg	do	Job Cook	Freestone	do
55	Monongahela city	do	William Nelson	Sandstone	do
56	Sewickley	Allegheny	United States Government	Sandstone	Sandstone
57	Walker's Mills	do	Pittsburg, Cincinnati, and Saint Louis R. R. Co.	do	do
58	do	do	Isaac Walker	do	do
59	Mansfield Valley	do	M. B. Brown	do	do
60	Pittsburgh	do	Thos. Rourke	do	do
61	Pittsburgh	Allegheny	Jesse P. Scharf	Sandstone	Sandstone
62	do	do	Evan Jones	do	do
63	do	do	Scott Bros	do	do
64	do	do	George Wright	do	do
65	do	do	Ali Harrison	do	do
66	Allegheny	Allegheny	Henry Jones	Sandstone	Sandstone
67	do	do	Ritchie & Scribner	do	do
68	do	do	Jacob Smith	do	do
69	do	do	John Hockenstein	do	do
70	do	do	Charles King	do	do
71	Allegheny	Allegheny	Lind Alexander	Sandstone	Sandstone
72	Bakerstown	Beaver	I. G. Gallagher	do	do
73	Baker's Landing	do	Reed & Ewing	do	do
74	Beaver Falls	do	Jos. Hartman	do	do
75	Homewood	do	A. Laird	do	do
76	Wampum	Lawrence	Jacob Friday	Sandstone	Sandstone
77	Sharon	Mercer	Jno. T. Anderson	do	do
78	do	do	Clemens Herrmann	do	do
79	Greenville	do	P. Leech	do	do
80	Shenango	do	Cross Parkerton & Co	do	do
81	Greenville	Mercer	Aley & Koppenberger	Sandstone	Sandstone
82	do	do	Alex A. Brown	do	do
83	do	do	Charles Fry	do	do
84	Stoneboro	do	L. W. Odell	do	do
85	Franklin	Venango	Joseph Bell & Son	do	do
86	Franklin	Venango	W. Bradford	Sandstone	Sandstone
87	Oil City	do	David Ready	do	do
88	Garland	Warren	Lucas & Brown	do	do
89	do	do	Pennsylvania Railroad Company	do	do
90	Titusville	Crawford	Denis Brenan	do	do
91	Meadville	Crawford	B. McNeil	Sandstone	Sandstone
92	do	do	Frank Beck	do	do
93	Corry	Erie	J. M. Colegrove	do	do
94	Lowell	do	Frank Sweet	do	do
95	Erie (4 miles east of)	do	James Leask	do	do

PENNSYLVANIA—SLATE.

1	East Bangor	Northampton	Bray & Short	Slate	
2	do	do	Star Slate Company	do	
3	Bangor	do	Bangor Slate Company	do	
4	do	do	Bangor Union Slate Company	do	
5	do	do	North Bangor Manufacturing Company	do	
6	Pen Argyl	Northampton	John Jackson & Co	Slate	
7	do	do	H. Doty & Co	do	
8	do	do	West Bangor Slate Company	do	
9	do	do	Stephen Jackson & Co	do	
10	Chapman's station	do	Chapman and New York Slate Company	do	
11	6 miles northwest of Catasauqua; 9 miles from Allentown.	Lehigh	North Peach Bottom Slate Company	Slate	
12	3½ miles east of Slatington	do	R. Henry & Co	do	
13	1½ miles east of Slatington	do	John Paulus & Co	do	
14	1 mile east of Slatington	do	Casket & Limack	do	
15	Slatington	do	James Bess & Co	do	
16	Slatington	Lehigh	W. H. Seibert	Slate	
17	do	do	David Williams	do	
18	½ mile west of Slatington	do	Columbia Slate Company	do	
19	do	do	Kunz & Jacobs	do	
20	West of Slatington	do	The Industrial Slate Company	do	
21	West of Slatington	Lehigh	Kunz & Maser	Slate	
22	Slatington	do	Joel Noll	do	
23	Slatedale	do	Locker Slate Company	do	
24	Lanesford	do	Laurel Hill Slate Company	do	
25	1 mile west of Stinesville	do	Kerver & Lutz	do	
26	1½ miles west of Stinesville	Lehigh	Griesimer & Bro	Slate	
27	Bangor	York	Peach Bottom Slate Manufacturing Co	do	
28	West Bangor	do	Jones & McLaughlin	do	
29	do	do	Robert L. Jones & Co	do	
30	½ mile from West Bangor	do	William C. Parry & Co	do	

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

PENNSYLVANIA—Sandstone—Continued.

Color.	Structure.			Geological age of formation.		Year in which quarried.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Gray	Coarse	Indistinct	Even, thin to thick	Carboniferous		1867	46
do	do	Irregular	Bowlders	do		1840	47
Light gray	Medium	do	Even, thin	Sub-Carboniferous		1876	48
Gray	Coarse	Massive	Even, thick	Carboniferous		1850	49
do	do	do	do	do		1880	50
Gray	Coarse	Irregular	Solid	Carboniferous		1860	51
do	do	do	Even, medium to thick	do		1880	52
do	do	do	do	do		1840	53
do	Medium	Even, parallel	Even, thin to medium	do		1847	54
do	Coarse	Massive	Even, thick	do		1850	55
Gray	Medium	Massive	Even, thick	Carboniferous		1850	56
do	do	Irregular	Even, medium to thick	do		1864	57
do	do	do	do	do		1848	58
do	do	do	Uneven, medium to thick	do		1850	59
do	do	do	Even, thin to thick	do		1843	60
Gray	Medium	Irregular	Even, thin to thick	Carboniferous		1845	61
do	do	do	do	do		1845	62
do	do	do	do	do		1840	63
do	do	do	do	do		1864	64
do	do	do	do	do		1845	65
Gray	Medium	Irregular	Even, thin to thick	Carboniferous			66
do	do	do	do	do		1869	67
do	do	do	do	do		1843	68
do	do	do	do	do		1843	69
do	do	do	do	do		1843	70
Gray	Medium	Irregular	Even, thin to thick	Carboniferous		1876	71
do	Coarse	Massive	Even, thick	do		1840	72
do	do	do	do	do		1880	73
do	do	Irregular	Even, thin to thick	do		1876	74
Gray and brown	do	do	Uneven, thick	do		1880	75
Gray	Coarse	Massive	Even, thick	Carboniferous		1869	76
do	do	do	Medium to thick	do		1872	77
do	do	do	Even, medium to thick	do		1875	78
do	Fine	Even, parallel	Even, thin	do		1868	79
do	do	do	do	do		1876	80
Gray	Fine	Even, parallel	Even, thin	Carboniferous		1871	81
do	do	do	do	do		1864	82
do	do	do	do	do		1876	83
Gray and light brown	Coarse	Massive	Irregular, medium to thick	do		1865	84
Gray	Fine	Even, parallel	Even, thin to medium	Sub-Carboniferous		1865	85
Gray	Fine	Even, parallel	Even, thin to medium	Sub-Carboniferous		1869	86
do	Coarse	Massive	Even, thick	Carboniferous		1869	87
do	do	do	do	do		1872	88
do	do	do	do	do		1867	89
do	do	do	do	Sub-Carboniferous		1867	90
Gray	Coarse	Massive	Even, thick	Carboniferous		1879	91
do	do	do	do	do		1875	92
do	Fine	Variable	Uneven, medium	Sub-Carboniferous		1868	93
do	do	Even, parallel	Even, medium	Devonian		1840	94
do	do	Indistinct	do	do		1865	95

PENNSYLVANIA—Slate.

Dark blue	Fine	Irregular	Smooth, even	Lower Silurian		1863	1
do	do	do	Smooth	do		1867	2
do	do	do	do	do		1865	3
do	Compact	do	Even	do		1872	4
do	do	do	do	do		1872	5
Dark blue	Compact	Irregular	Smooth	Lower Silurian		1875	6
do	do	do	do	do		1853	7
do	Fine	Do	do	do		1872	8
do	do	do	Smooth, even	do		1875	9
Blue-black	do	Variable		do		1875	10
Blue-black	Fine	Rhomboidal	Even	Lower Silurian		1845	11
Blue	do	Irregular	do	do		1846	12
Dark blue	do	Rectangular		do		1857	13
Black	do	do		do		1857	14
Dark blue	do	do		do		1848	15
Dark blue and black	Fine	Irregular	Smooth, even	Lower Silurian		1865	16
Black	do	do		do		1864	17
Dark blue	do	Rhomboidal		do		1865	18
do	do	do		do		1853	19
do	Hard	Rectangular		do		1866	20
Dark blue	Fine	Rectangular		Lower Silurian		1848	21
do	do	Irregular	Smooth	do		1849	22
do	do	do		do		1860	23
Blue	do	do		do		1877	24
Dark blue	do	do	Even	do		1878	25
Dark blue	Tough	Rectangular	Smooth	Lower Silurian		1867	26
Blue-black	Fine	Irregular		Archæan (?)		1846	27
Dark blue	do	do	Even, smooth	do		1881	28
Blue-black	do	do	do	do		1852	29
Dark blue	do	do	do	do		1835	30

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

DELAWARE—CRYSTALLINE SILICEOUS ROCKS.

	Location of quarry	County	Name of the corporation, company, or individual.	Specific variety of stone	
				Popular name.	Scientific name.
1	[illegible]	[illegible]	[illegible]	Granite	
2	do	do	Hughes & Walker	do	
3	do	do	James McKendrick	do	

MARYLAND—CRYSTALLINE SILICEOUS ROCKS.

1	[illegible]	[illegible]	[illegible]	Granite	Biotite gneiss
2	[illegible]	[illegible]	McClenahan & Brother	do	do
3	[illegible]	[illegible]	[illegible]	Gneiss	do
4	[illegible]	[illegible]	[illegible]	Granite	Biotite granite
5	[illegible]	[illegible]	[illegible]	do	do
6	[illegible]	[illegible]	[illegible]	Granite	Biotite granite
7	Opposite Ellicott City	do	[illegible]	do	Biotite gneiss

MARYLAND—MARBLE AND LIMESTONE.

1	Cockeysville	[illegible]	[illegible]	Marble	
2	[illegible]	[illegible]	T. Gladders	Limestone	Magnesian limestone
3	[illegible]	do	Swartz Quarry	do	do

MARYLAND—SLATE.

1	[illegible]	[illegible]	W. E. Williams & Co	Slate	
2	[illegible]	[illegible]	Thomas W. Jones & Co	do	
3	do	do	[illegible]	do	
4	do	do	[illegible]	do	
5	do	do	W. C. Roberts & Co	do	
6	[illegible]	[illegible]	John A. Barnett & Co	Slate	
7	do	do	Bartlett Peach Bottom Slate Company	do	

VIRGINIA—CRYSTALLINE SILICEOUS ROCKS.

1	[illegible]	[illegible]	Chase Andrews	Diabase	Diabase
2	[illegible]	Spotsylvania	[illegible]	Granite	Biotite-muscovite granite
3	[illegible]	[illegible]	J. B. Mitchell & Co	do	Biotite granite
4	[illegible]	[illegible]	[illegible]	do	do
5	[illegible]	[illegible]	[illegible]	do	do
6	[illegible]	Chesterfield	[illegible]	Granite	Biotite granite
7	[illegible]	Campbell.	[illegible]	Gneiss and mica-schist.	Biotite gneiss
8	[illegible]	[illegible]	[illegible]	Granite	do
9	Namozine district	[illegible]	[illegible]	Granite	Biotite granite
10	[illegible]	do	[illegible]	do	do

VIRGINIA—MARBLE AND LIMESTONE.

1	[illegible]	[illegible]	[illegible]	Slate	
2	[illegible]	[illegible]	[illegible]	Marble	Magnesian limestone and limestone

VIRGINIA—SLATE.

1	[illegible]	[illegible]	J. R. Williams & Co	Slate	
2	[illegible]	[illegible]	[illegible]	do	

WEST VIRGINIA—SANDSTONE.

1	Wheeling	Ohio	Adolph Yhaka	Sandstone	Sandstone
2	[illegible]	[illegible]	[illegible]	do	do
3	[illegible]	[illegible]	[illegible]	do	do
4	[illegible]	[illegible]	[illegible]	do	do
5	[illegible]	[illegible]	[illegible]	do	do
6	[illegible]	[illegible]	Baltimore and Ohio Railroad Company	Sandstone	Sandstone
7	Parkersburg	Wood	R. P. Tatum	do	do
8	do	do	Nugent Kinnan	do	do
9	[illegible]	do	Patrick Conway	do	do
10	New Charleston	Kanawha	Joel T. Quarrier and others	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

DELAWARE—Crystalline Siliceous Rocks.

Color.	Structure.			Geological age of formation.		Year in which quarried.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Black	Medium	Laminated	Irregular	Archæan		1872	1
do	do	do	do	do		1876	2
do	do	do	do	do		1873	3

MARYLAND—Crystalline Siliceous Rocks.

Dark gray	Coarse	Wavy	Vertical	Archæan		1840	1
do	do	do	Inclined sheets	do		1825	2
Dark greenish gray	Fine	Even, parallel	Irregular	do		1830	3
Gray	Coarse	Indistinctly laminated	Horizontal sheets	do		1839	4
do	Fine	do	Irregular	do		1879	5
Gray	Coarse	Massive	Inclined sheets	Archæan		1836	6
Dark gray	do	Wavy	Horizontal and vertical	do		1872	7

MARYLAND—Marble and Limestone.

White	Fine and coarse crystalline.	Massive	Uneven, thick	Lower Silurian	Auroral	1849	1
Dark blue	Fine	Irregular	do	do	do		2
Blue	do	do	do	do	do		3

MARYLAND—Slate.

Bluish black	Fine	Rhomboidal	Silky fracture	Archæan		1849	1
do	do	do	do	do		1870	2
do	do	do	do	do		1870	3
do	Fine and clear	do	Even and smooth	do		1867	4
do	do	do	do	do		1866	5
Bluish black	Fine and clear	Rhomboidal	Medium smooth	Archæan		1870	6
Dark blue	do	Irregular	Even	do		1872	7

VIRGINIA—Crystalline Siliceous Rocks.

Dark gray	Fine	Massive	Broken, irregular	Mesozoic (Trias)		1880	1
Light gray	Medium	Indistinctly laminated	Vertical and horizontal	Archæan		1880	2
Gray	do	Massive	do	do		1880	3
do	do	do	Irregular	do		1835	4
do	do	do	Inclined sheets	do		1850	5
Light gray	Fine	Massive	Horizontal sheets	Archæan		1837	6
Blue	do	Laminated	Irregular	do		1867	7
do	do	Massive	Inclined sheets	do		1858	8
Greenish gray	Medium	Indistinctly laminated	Few joints	do		1880	9
do	do	do	Solid	do		1879	10

VIRGINIA—Marble and Limestone.

Drab	Fine	Even, parallel	Vertical and transverse	Lower Silurian		1879	1
Pinkish gray	Fine semi-crystalline, fossiliferous.	Indistinct	Uneven, thick	Upper Silurian		1879	2

VIRGINIA—Slate.

Bluish black	Fine	Rectangular	Even smooth	Archæan		1880	1
do	do	do	do	do		1859	2

WEST VIRGINIA—Sandstone.

Light gray	Coarse	Irregular	Even, thick	Carboniferous	Upper Coal Measures.	1876	1
do	do	do	do	do	do	1860	2
do	do	do	do	do	do	1852	3
do	do	do	do	do	do	1892	4
Dark gray	Fine, compact	Even, parallel	do	Devonian	Catskill?	1877	5
Reddish gray	Coarse	Massive	Even, thick	Carboniferous	Barren Measures	1870	6
Gray	Medium	Even, parallel	do	do	Upper Coal Measures	1877	7
do	do	do	do	do	do	1859	8
do	do	do	do	do	do	1879	9
do	Coarse	do	Uneven, thick	do	Barren Measures	1880	10

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

GEORGIA—CRYSTALLINE SILICEOUS ROCKS.

	Location of quarry.	County.	Name of the corporation, company, or individual	Specific variety of stone.	
				Popular name.	Scientific name.
1	Atlanta	Fulton	Patrick Lynch	Granite	Hornblende-biotite gneiss
2	16 miles from Atlanta	De Kalb	Callahan & Welsh	do	Muscovite granite

GEORGIA—SLATE.

1	Rock Mart	Polk	G. W. Jones & Co	Slate	

TENNESSEE—MARBLE AND LIMESTONE.

1	Near Rogersville	Hawkins	Chestnut & Chestnut Crescent quarry	Marble	Limestone
2	4½ miles from Rogersville	do	John Hasson	do	do
3	Morristown	do	E. D. Dougherty	do	do
4	7 miles from Whitesburg	do	Joseph Stamps (Star quarry)	do	do
5	4 miles from Knoxville	Knox	Knoxville Marble Company	do	do
6	2 miles from Knoxville	Knox	Freeman & Morgan	Marble	Limestone
7	1 mile from Knoxville	do	John M. Rose	do	do
8	5½ miles southwest of Knoxville	do	Tennessee River Marble Company	do	do
9	9 miles from Cleveland	Bradley	Patrick & Smith	do	Magnesian limestone and limestone.
10	2 miles from Chattanooga	Hamilton	Dunstick Slate	Limestone	Magnesian limestone
11	Near Nashville	Davidson	Williams & Jones	Limestone	Siliceous dolomite and limestone
12	do	do	Callahan & Welsh	do	
13	Near Clarksville	Montgomery	John Conroy	do	

KENTUCKY—MARBLE AND LIMESTONE.

1	Newport	Campbell	Fitzsimmons & Sons	Limestone	Limestone
2	do	do	H. & F. Pechine	do	do
3	West of Covington	Kenton	[illegible] Fathers	do	do
4	do	do	W. Clark	do	do
5	do	do	J. W. Rich	do	do
6	South of Covington	Kenton	Thomas Woods	Limestone	Limestone
7	On Ohio river	Pendleton	Davis Irwin	do	do
8	1 mile east of Louisville	Jefferson	Mackey Johnson	do	Magnesian limestone
9	Louisville	do	City of Louisville	do	do
10	do	do	Dennis Mooney	do	do
11	Louisville	Jefferson	A. Stough	Limestone	Magnesian limestone
12	do	do	Joseph Nevin	do	do
13	do	do	George Faust	do	do
14	do	do	John Johnson	do	do
15	do	do	A. Holtcher	do	do
16	Leaches	Bullitt	Louisville & Nashville Railroad Company	Limestone	Magnesian limestone
17	Lexington	Fayette	City of Lexington	do	Limestone
18	Near Bowling Green	Warren	Belknap Drumsville Stone Company	do	Bituminous limestone
19	2½ miles east of Princeton	Caldwell	Princeton Stone and Marble Company	do	do

OHIO—SANDSTONE.

1	3 miles north of Wakeman	Erie	Nicholl & Miller	Sandstone	Sandstone
2	Berea Heights	do	G. A. Radlie	do	do
3	Brownhelm	Lorain	Worthington & Sons	do	do
4	Amherst	do	do	do	do
5	do	do	L. Haldeman & Sons	do	do
6	Amherst	Lorain	Amherst Stone Company	Sandstone	Sandstone
7	do	do	Wilson & Hughes	do	do
8	do	do	W. H. Bryant	do	do
9	do	do	James Nicholl	do	do
10	do	do	Clough Stone Company	do	do
11	Grafton	Lorain	W. E. Miller	Sandstone	Sandstone
12	Elyria	do	Massey & Co	do	do
13	do	do	John Weller	do	do
14	2 miles north of Elyria	do	John Eschtruth	do	do
15	Ridgeville	do	H. L. Beebe	do	do
16	West View	Cuyahoga	Columbia Stone Company	Sandstone	Sandstone
17	Olmsted Falls	do	L. Barnum	do	do
18	Eaton	do	McDermott & Berea Stone Company	do	do
19	2 miles east of Berea	do	Barnard Rafferty	do	do
20	Brooklyn	do	Jacob Hoehn	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

GEORGIA—Crystalline Siliceous Rocks.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Blue	Fine	Massive	Irregular	Archæan		1854	1
Light gray	do	do	Horizontal and inclined sheets.	do		1865	2

GEORGIA—Slate.

Blue	Fine	Irregular	Even	Archæan	1859	1

TENNESSEE—Marble and Limestone.

Variegated	Fine, semi-crystalline	Massive	Thick	Lower Silurian	1880	1
do	Fine, compact, semi crystalline, fossiliferous.	do	do	do	1872	2
do	Fine, semi-crystalline, fossiliferous.	do	do	do	1854	3
do	do	do	do	do	1873	4
Pinkish gray	Medium, semi-crystalline	do	Medium to thick	do	1869	5
Pinkish gray	Medium, semi-crystalline	Massive	Even, thick	Lower Silurian	1879	6
Pink	do	do	Thick	do	1879	7
Pinkish gray	Medium, semi-crystalline, fossiliferous.	do	do	do	1880	8
do	Medium, semi-crystalline	do	do	do	1879	9
Blue-black	Fine, compact	do	Medium to thick	do	1855	10
Gray	Fine, compact	Massive	Medium to thick	Lower Silurian	1877	11
do	do	do	Thick	do	1840	12
do	do	do	Medium to thick	Sub-Carboniferous	1869	13

KENTUCKY—Marble and Limestone.

Blue	Semi-crystalline, fossiliferous.	Massive	Even, thin to medium	Lower Silurian (Cincinnati).	1867	1
do	do	do	do	do	1870	2
do	do	do	do	do	1870	3
do	do	do	do	do	1876	4
do	do	do	do	do	1860	5
Blue	Semi-crystalline, fossiliferous.	Massive	Even, thin to medium	Lower Silurian (Cincinnati).	1876	6
do	do	do	do	do	1871	7
Drab	Semi-crystalline	do	Even, medium	Sub-Carboniferous	1858	8
do	do	do	do	do	1870	9
do	do	do	Even, thick	do	1879	10
Drab	Semi-crystalline	Massive	Even, thick	Sub-Carboniferous	1877	11
do	do	do	Medium to thick	do	1850	12
do	do	do	do	do	1870	13
do	do	do	Even, medium to thick	do	1855	14
do	do	do	do	do	1865	15
Drab	Medium, fine	Massive	Even, thick	Sub-Carboniferous	1864	16
Gray	Semi-crystalline, fossiliferous.	do	Even, thin to medium	Lower Silurian	1850	17
do	Granular, fossiliferous	do	Even, medium to thick	Sub-Carboniferous	1872	18
do	Oolitic and compact	do	Even, thick	do	1878	19

OHIO—Sandstone.

Gray	Medium	Variable	Even, thickness varies	Sub-Carboniferous	Berea grit	1876	1
do	do	do	do	do	do	1870	2
do	do	do	do	do	do	1848	3
do	do	do	do	do	do	1856	4
do	do	do	do	do	do	1870	5
Gray	Medium	Variable	Even, thickness varies	Sub-Carboniferous	Berea grit	1872	6
do	do	do	do	do	do	1835	7
do	do	do	do	do	do	1874	8
do	do	do	do	do	do	1845	9
do	do	do	do	do	do	1852	10
Gray	Medium	Variable	Even, thickness varies	Sub-Carboniferous	Berea grit	1860	11
do	do	do	do	do	do	1871	12
do	do	do	do	do	do	1865	13
do	do	do	do	do	do	1873	14
do	do	do	do	do	do	1875	15
Gray	Medium	Variable	Even, thickness varies	Sub-Carboniferous	Berea grit	1867	16
do	do	do	do	do	do	1855	17
do	Fine	do	do	do	do	1840	18
do	Medium	do	Uneven, thickness varies	do	do	1876	19
do	do	Coarse	Even, thickness medium	do	do	1840	20

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

OHIO—SANDSTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
21	Brooklyn	Cuyahoga	Anthony James' estate	Sandstone	Sandstone
22	East Cleveland	do	James Hayeox	do	do
23	do	do	C. E. Kreider	do	do
24	do	do	W. G. Scott	do	do
25	do	do	G. P. Gale	do	do
26	Bedford	Cuyahoga	Bedford Stone Company	Sandstone	Sandstone
27	Independence	do	J. B. Blaisdell	do	do
28	do	do	F. D. Smith	do	do
29	do	do	Watson & Hughes	do	do
30	Newburgh	do	Edwards Brothers	do	do
31	Newburgh	Cuyahoga	W. H. Crane	Blue-stone	Sandstone
32	do	do	Richard Blaisdell	do	do
33	do	do	J. C. Crandell	do	do
34	Euclid	do	Maxwell & Malone	do	do
35	do	do	John Wagner	do	do
36	Euclid	Cuyahoga	Forest City Stone Company	Blue-stone	Sandstone
37	do	do	Michael and Brothers	do	do
38	do	do	Savage, Hooker & Co.	do	do
39	Windsor	Ashtabula	Lorain Stone Company	Sandstone	Sandstone
40	Mesopotamia	Trumbull	Mesopotamia Freestone Company	Freestone	do
41	3 miles northwest of Warren	Trumbull	Austin Flagstone Company	Flag-stone	Sandstone
42	West Warren	do	Brownville Ridge Quarries	Sandstone	do
43	Wyndham	Portage	Case & Kurt	do	do
44	Twinsburg	Summit	Gardner Brownlee	do	do
45	do	do	Newton Herrick	do	do
46	Akron	Summit	Joseph Bagell	Sandstone	Sandstone
47	do	do	Wilhelm & Schroeder	do	do
48	Northampton township	do	Brown & Bloom	Limestone	do
49	Berger's	do	Ferdinand Schumacher	Sandstone	do
50	Greenfield	Huron	George Graham	Flag-stone	do
51	3 miles west of Norwalk	Huron	William Perrin	Sandstone	Sandstone
52	3 miles south of Norwalk	do	Charles Gramell	do	do
53	Maplewa	Lucas	Samuel Wagner	do	do
54	Lowville	Crawford	Lowville Stone Company	do	do
55	do	do	Morrow & Miller	do	do
56	Plymouth	Richland	S. W. Tuttle	Sandstone	Sandstone
57	do	do	Wakefield Brown	do	do
58	Mansfield	do	Christian Voetsch	do	do
59	do	do	Tobey & Cline	do	do
60	Weller township	do	Hayes & Cottel	do	do
61	Weller township	Richland	S. Stavely	Sandstone	Sandstone
62	Belleville	do	D. W. Zent	do	do
63	Wooster	Wayne	Coe Brothers	do	do
64	Warwick	do	Walnut Grove Stone Company	do	do
65	West of Massillon	Stark	Wattlorst & Co.	do	do
66	Northwest of Massillon	Stark	Suter & Eichard	Sandstone	Sandstone
67	3 miles north of Massillon	do	John Paul	do	do
68	3 miles west of Massillon	do	John Vogt	do	do
69	Youngstown	Mahoning	Kirk Quarry, John Holden	do	do
70	2 miles northwest of Youngstown	do	Brier Hill Stone Company	do	do
71	2½ miles southwest of Youngstown	Mahoning	Thomas Connell	Sandstone	Sandstone
72	New Wilmington	do	New Castle Quarries	do	do
73	New Castle	Columbiana	J. H. O'Neil	do	do
74	Underwood or Caseyville	Logan	D. M. Sparrow	do	do
75	5 miles north of Canal Dover	Tuscarawas	Tuscarawas Valley Coal and Iron Company	do	do
76	3 miles west of New Philadelphia	Tuscarawas	Alfred Mathias	Sandstone	Sandstone
77	Black Hand, south of Millersburg	Holmes	W. H. Lang	do	do
78	Northeast of Mount Vernon	Knox	Bartlett Brothers	do	do
79	10 miles east of Mount Vernon	do	Isaac Critchfield	do	do
80	Washington township	Morrow	Green & Coyle	do	do
81	North Cincinnati	Morrow	John Flowers	Sandstone	Sandstone
82	Zoar	do	Wilson & Shattuck	do	do
83	do	do	Crane Brothers	do	do
84	3 miles south of Berlin	do	William Goorley	do	do
85	Woodbridge	do	E. S. Russell	do	do
86	Underwood or Carlington	Morrow	Robert Edgell	Sandstone	Sandstone
87	do	do	W. Brooke	do	do
88	Ostrander	Delaware	H. Thorpe	do	do
89	do	do	C. B. Gaylord	do	do
90	10 miles east of Columbus	Franklin	William A. Forrester	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

OHIO.—SANDSTONE.—Continued.

Color.	STRUCTURE			GEOLOGICAL AGE OF FORMATION.		Year in which opened	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Gray	Medium	Coarse	Even, thickness medium	Sub-Carboniferous	Berea grit	1845	21
do	do	do	do	do	do	1849	22
do	do	do	do	do	do	1850	23
do	do	do	do	do	do	1854	24
do	do	do	do	do	do	1854	25
Gray	Medium	Coarse	Irregular	Sub-Carboniferous	Berea grit	1855	26
do	do	do	do	do	do	1855	27
do	do	do	do	do	do	1855	28
do	do	do	do	do	do	1855	29
do	do	do	Uneven, thickness medium	do	do	1855	30
Gray	Fine	Massive	Even, thickness medium	Sub-Carboniferous	Bedford shale	1855	31
do	do	do	do	do	do	1855	32
do	do	do	do	do	do	1855	33
do	do	do	do	do	do	1855	34
do	do	do	do	do	do	1855	35
Gray	Fine	Massive	Even, thickness medium	Sub-Carboniferous	Bedford shale	1855	36
do	do	do	do	do	do	1855	37
do	do	do	do	do	do	1855	38
do	Variable	Even, thickness varies	do	do	Berea grit	1857	39
do	Medium	do	do	do	do	1854	40
Dark gray	Fine	Fine	Even, thin	Sub-Carboniferous	Cuyahoga shale	1857	41
Gray	Coarse	Coarse	Irregular, thick	Carboniferous	Base of Lower Coal Measures.	1859	42
Light gray	do	Massive	do	do	do	1857	43
Gray	do	do	Even, thick	do	do	1859	44
do	do	do	do	do	do	1854	45
Gray	Coarse	Coarse	Uneven, thick	Carboniferous	Base of Lower Coal Measures	1857	46
do	do	do	do	do	do	1896	47
do	Fine	Massive	Even, variable, thick	Sub-Carboniferous	Berea grit	1857	48
do	Medium	Coarse and massive	Even, thick	do	do	1859	49
do	Fine	Fine and irregular	Regular	do	do	1859	50
Gray	Medium	Variable	Even, variable, thick	Sub-Carboniferous	Berea grit	1857	51
do	do	do	Even, thin to medium	do	do	1859	52
Dark gray	Coarse	Massive	Even, medium, thick	Devonian	Lower Carboniferous	18	53
do	Fine	Fine and massive	Even, variable, thick	Sub-Carboniferous	Berea grit	1859	54
do	do	do	do	do	do	1857	55
Gray	Fine	Massive	Uneven, medium, thick	Sub-Carboniferous	Berea grit	1857	56
do	Coarse	Coarse	Even, medium, thick	do	do	1857	57
Gray and brown	Coarse	Massive	do	do	Waverly conglomerate	1859	58
Gray	do	do	do	do	do	1857	59
do	do	do	Even, thick	do	do	1857	60
Gray	Coarse	Massive	Even, thick	Sub-Carboniferous	Waverly conglomerate	1875	61
Gray and brown	do	Coarse	Even, variable, thick	do	do	1857	62
Gray	do	Massive	do	do	do	1857	63
do	do	do	Even, thick	Carboniferous	Base of Lower Coal Measures	1859	64
Gray and pink	do	do	Uneven, thick	do	Lower Coal Measures	1885	65
Gray and pink	Coarse	Massive	Uneven, thick	Carboniferous	Lower Coal Measures	1885	66
do	Medium	do	do	do	do	1870	67
do	Coarse	do	do	do	do	1857	68
Gray	Medium	do	Even, thick	Carboniferous	Base of Lower Coal Measures	1874	69
do	do	Coarse and irregular	do	do	Lower Coal Measures.	1885	70
Gray	Medium	Coarse and irregular	Even, thick	Carboniferous	Lower Coal Measures	1885	71
Light brown	Coarse	Coarse and massive	Uneven, variable, thick	do	do	1859	72
Gray	do	Irregular	Thick	do	do	1856	73
do	do	Massive	Uneven, thick	do	do	1856	74
do	do	do	do	do	do	1856	75
Gray	Coarse	Massive	Even, thick	Carboniferous	Lower Coal Measures	1856	76
do	do	do	do	do	do	1856	77
do	do	Coarse and massive	Even, thick	do	Base of Lower Coal Measures	1856	78
do	do	Coarse	Even, variable	Sub-Carboniferous	Waverly conglomerate	1875	79
do	Fine	Fine and massive	Uneven, medium	do	Berea grit	1856	80
Gray	Fine	Fine and massive	Uneven, medium	Sub-Carboniferous	Berea grit	1875	81
Dark gray	do	Slightly irregular	Irregular, smooth	do	do	1856	82
do	do	do	do	do	do	1856	83
Gray	do	Fine and massive	Uneven, thin to medium	do	do	1856	84
do	do	do	do	do	do	1857	85
Gray	Fine	Fine and massive	Uneven, thin to medium	Sub-Carboniferous	Berea grit	1859	86
do	do	do	do	do	do	1856	87
do	do	do	Even, thin to medium	do	do	1856	88
do	do	do	do	do	do	1857	89
do	do	Massive	Even, medium	do	do	1856	90

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

OHIO—SANDSTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE	
				Popular name.	Scientific name.
91	Newark	Licking	James Coyle	Freestone	Sandstone
92	8 miles east of Newark	do	Charles Daugherty	Sandstone	do
93	do	do	O. Z. Hillery	do	do
94	2 miles southwest of Coshocton	Coshocton	Moses Cheney	do	do
95	Roscoe	do	Robert Dickinson	do	do
96	Zanesville	Muskingum	T. B. Townsend	Sandstone	Sandstone
97	Cumberland	Guernsey and Noble.	do	do	do
98	2½ miles northwest of Cambridge	Guernsey	Samuel Barr	do	do
99	2 miles southeast of Tipperanoe	Harrison	Robert Hosie	do	do
100	West side of Steubenville	Jefferson	Floto & Brothers	do	do
101	West side of Steubenville	Jefferson	Archer & Boal	Sandstone	Sandstone
102	West side of Martin's Ferry	Belmont	Charles Seabreght	do	do
103	2 miles west of Bellaire	do	John R. Robinson	do	do
104	West side of Bellaire	do	W. J. McCoan	do	do
105	Lewis Mills	do	Joseph Hutchinson	do	do
106	Barnesville	Belmont	Baltimore and Ohio Railroad Company	Sandstone	Sandstone
107	Marietta	Washington	T. B. Townsend	do	do
108	2 miles southwest of Marietta	do	C. Finch	do	do
109	6 miles southwest of Marietta	do	Marietta Stone Company	do	do
110	do	do	Constitution Stone Company	do	do
111	7 miles southwest of Marietta	Washington	P. L. Cole	Sandstone	Sandstone
112	8 miles southwest of Marietta	do	D. Briggs	do	do
113	8½ miles southwest of Marietta	do	D. B. Calder	do	do
114	2½ miles west of Constitution	do	Constitution Stone Company	do	do
115	Lockpodts	Fairfield	Joseph Leydecker	Freestone	do
116	Lancaster	Fairfield	Charles Bowmaster	Sandstone	Sandstone
117	Lancaster (east)	do	Sharp & Crook	do	do
118	Lancaster (south)	do	do	do	do
119	Logan	Hocking	Wentzell Brothers	do	do
120	Piketon	Pike	Hays & Green	do	do
121	Piketon	Pike	Waverly Brown Stone Quarries	Freestone	Sandstone
122	2 miles west of Portsmouth	Scioto	Reitz & Co	do	do
123	12 miles from Portsmouth	do	J. M. Bushkop	do	do
124	Freestone P. O. (Buena Vista)	do	Buena Vista Freestone Company	do	do
125	Freestone	Scioto & Adams	John M. Mueller	do	do
126	Rockville	Scioto & Adams	W. J. Stewart	Freestone	Sandstone

OHIO—LIMESTONE.

1	Point Marblehead	Ottawa	Fred. Rousling	Limestone	Bituminous dolomite
2	do	do	Clemons & Sons	do	do
3	do	do	Johnson & Clemons	do	do
4	do	do	W. A. Clemons	do	do
5	do	do	Ohlemacher Bros	do	do
6	Point Marblehead	Ottawa	John H. Hudson	Limestone	Bituminous dolomite
7	do	do	John H. James	do	do
8	Johnsons island	do	L. B. Johnson & Co	do	do
9	White House	Lucas	Pray & Hall	do	Magnesian limestone
10	5 miles from Weston	Wood	L. S. Pugh	do	Dolomite
11	1 mile west of Fremont	Sandusky	Quilter Brothers	Limestone	Bituminous dolomite
12	Kelley's island	Erie	N. Kelley & Co	do	Dolomite
13	Sandusky	do	Dr. T. Davis	do	do
14	do	do	David McGoray	do	do
15	do	do	Watson Hubbard	do	do
16	Sandusky	Erie	Charles Schoepfle	Limestone	Dolomite
17	do	do	Ambrose Lieb	do	Bituminous dolomite
18	do	do	Michael Callan	do	Dolomite
19	do	do	Michael O'Donnell	do	do
20	Bloomville	Seneca	Fred. Seavert	do	Magnesian limestone
21	Bloomville	Seneca	A. Reichert	Limestone	Magnesian limestone
22	do	do	E. H. France	do	do
23	Tiffin	do	J. L. King	do	Bituminous dolomite
24	do	do	H. W. Creeger	do	do
25	do	do	Thill & Graesner	do	do
26	Holmes township	Crawford	L. B. Gearhart	Limestone	Dolomite
27	Findlay	Hancock	Altman & Pressnell	do	Bituminous magnesian limestone
28	do	do	L. J. Turley	do	do
29	1 mile east of Findlay	do	L. Hershey	do	do
30	7 miles southwest of Ottawa	Putnam	John Hagel	do	Bituminous dolomite

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

OHIO—Sandstone—Continued.

Color.	Structure. Texture.	Structure. Stratification.	Structure. Jointing, bedding, or natural surface.	Geological age of formation. Period.	Geological age of formation. Epoch.	Year in which opened.	
Gray	Fine	Fine, not distinct	Even, thick	Sub-Carboniferous	Cuyahoga shale	1830	91
do	Coarse	Coarse and massive	do	do	Waverly conglomerate.	1854	92
do	do	do	do	do	do	1834	93
Gray and light red	do	do	One 30-foot stratum	Carboniferous	Lower Coal Measures.	1880	94
do	do	do	Even	do	do	1830	95
Gray	Coarse	Massive	One 40-foot stratum	Carboniferous	Lower Coal Measures.	1868	96
do	Medium	Fine, not distinct	One 10-foot stratum	do	Lower Barren Measures.	1855	97
Gray	Coarse	Massive	One 12-foot stratum	do	do	1850	98
do	do	Coarse and regular	Even, thick	do	do	a1881	99
do	do	Coarse and massive	do	do	Upper Coal Measures.	1870	100
Gray	Coarse	Coarse and massive	Even, thick	Carboniferous	Upper Coal Measures.	1872	101
do	do	Coarse and regular	One 30-foot stratum	do	do	1879	102
do	do	Massive	Even, thick	do	do	1875	103
do	Medium	Fine and variable	Even, medium	do	do	1865	104
do	Coarse	Variable and massive	Broken and irregular	do	do	1850	105
Gray	Coarse	Coarse and massive	One thick stratum	Carboniferous	Lower Barren Measures.	1867	106
do	do	do	Uneven, thick	do	Upper Coal Measures.	1880	107
do	Variable	Coarse and variable	One 25-foot stratum	do	do	1830	108
do	do	do	do	do	do	1830	109
do	do	do	do	do	do	1830	110
Gray	Variable	Coarse and variable	One 25-foot stratum	Carboniferous	Upper Coal Measures.	1830	111
do	do	do	do	do	do	1830	112
do	do	do	do	do	do	1830	113
do	do	do	do	do	do	1830	114
do	Fine	Massive	Even and thin to medium	Sub-Carboniferous	Cuyahoga shale	1830	115
Gray and red	Coarse	Massive	One 30-foot stratum	Sub-Carboniferous	Waverly conglomerate.	1865	116
Gray and brown	Coarse and fine	Coarse and massive	Even, thick	do	do	1878	117
do	do	do	do	do	do	1835	118
Gray	Coarse and conglomerate	Coarse	do	do	do	1879	119
do	Fine	Variable	Even, thin to medium	do	Berea grit	1830	120
Brown	Fine	Massive	Even, thick	Sub-Carboniferous	Cuyahoga shale	1870	121
Gray and brown	do	do	Even, medium thick	do	do	1865	122
Gray	do	do	Even, thin to medium	do	do	1874	123
do	do	do	Even, medium thick	do	do	1840	124
Dark gray	do	do	do	do	do	1849	125
Dark gray	Fine	Massive	Even, medium thick	Sub-Carboniferous	Cuyahoga shale	1814	126

a This quarry, though opened in 1881, was considered of sufficient importance to have a place in the tables.

OHIO—Limestone.

Gray	Semi-crystalline fossiliferous.	Massive	Even, medium to thick	Devonian	Corniferous	1830	1
do	do	do	do	do	do	1830	2
do	do	do	do	do	do	1850	3
do	do	do	do	do	do	1830	4
do	Semi-crystalline	do	do	do	do	1854	5
Gray	Fossiliferous	Massive	Even, medium to thick	Devonian	Corniferous	1840	6
do	do	do	do	do	do	1874	7
do	do	do	do	do	do	1850	8
do	Fine, compact, and vesicular.	Even and massive	Even and uneven, medium thick.	do	do	1860	9
do	Compact and vesicular	Massive	Uneven, thin to medium	do	do	1850	10
Gray	Vesicular	Parallel, wavy	Even, medium thick	Upper Silurian	Helderberg (waterlime).	1868	11
do	Semi-crystalline, fossiliferous.	Massive	do	Devonian	Corniferous	1857	12
Bluish gray	do	do	do	do	do	1837	13
do	do	do	do	do	do	1837	14
do	do	do	do	do	do	1837	15
Bluish gray	Semi-crystalline, fossiliferous.	Massive	Even, medium thick	Devonian	Corniferous	1874	16
do	do	do	do	do	do	1873	17
do	do	do	do	do	do	1873	18
do	do	do	do	do	do	1873	19
Drab	do	do	do	do	do	1877	20
Drab	Semi-crystalline, fossiliferous.	Massive	Even, medium thick	Devonian	Corniferous	1850	21
do	do	do	do	do	do	1880	22
do	Vesicular	Wavy and massive	do	Upper Silurian	Helderberg (waterlime).	1878	23
do	do	do	do	do	do	1868	24
do	do	do	do	do	do	1862	25
Gray and bluish gray	Compact	Massive	Uneven, thin to medium	Devonian	Corniferous	1866	26
Drab	Porous and vesicular	Irregular	do	Upper Silurian	Niagara	1875	27
do	do	do	do	do	do	1876	28
do	do	do	do	do	do	1874	29
Dark drab	Compact and vesicular, porphyritic.	Even, irregular, and massive.	Even, thin to medium	do	Helderberg (waterlime).	1845	30

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

OHIO—LIMESTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
31	2 miles north of Columbus Grove	Putnam	J. Postlewait	Limestone	Bituminous dolomite
32	3 miles northeast of Van Wert	Van Wert	Miss Z. Palmer	do	Dolomite
33	4 miles east of Delphos	Allen	A. J. Patton	do	Bituminous dolomite
34	Lima	do	William Pugh	do	do
35	4 miles north of Lima	do	Mrs. B. A. Armentrout	do	do
36	5½ miles northeast of Lima	Allen	Jacob Custer	Limestone	Bituminous dolomite
37	Bluffton	do	John T. Bates	do	do
38	do	do	Ritzler & Greenwald	do	do
39	6 miles northeast of Marion	Marion	F. Hinamon	do	Dolomite
40	1 mile north of Marion	do	Marion Stone Company	do	do
41	1 mile north of Marion	Marion	T. R. Roberts & Co	Limestone	Dolomite
42	Marion	do	Haberman & Riley	do	do
43	do	do	Beattie & Sherbonda	do	do
44	do	do	Peters & Lawrence	do	do
45	Delaware	Delaware	R. J. Akers	do	
46	½ mile east of Bell Centre	Logan	W. L. Sickles	Limestone	Bituminous dolomite
47	1 mile northwest of Bellefontaine	do	J. H. Eaton	do	Dolomite
48	½ mile northwest of Bellefontaine	do	Angel, Miller & Co	do	do
49	1 mile east of Sidney	Shelby	A. Hall & Son	do	Arenaceous magnesian limestone
50	½ mile west of Ludlow	Miami	G. Rumburg	do	Magnesian limestone
51	1 mile south of Covington	Miami	I. P. Watts & Co	Limestone	Arenaceous magnesian limestone
52	Covington	do	Conrad Shetbuch	do	do
53	do	do	N. W. Tuttas	do	do
54	do	do	Lewis Face	do	do
55	do	do	Butt & Battorff	do	do
56	Covington	Miami	J. W. Ruhl	Limestone	Arenaceous magnesian limestone
57	do	do	Covington Stone Company	do	do
58	1½ miles south of Piqua	do	D. C. Stattler & Co	do	Magnesian limestone
59	2½ miles south of Piqua	do	H. G. Dewese	do	do
60	At Piqua	do	H. Clark & Son	do	do
61	At Piqua	Miami	Mitchell & Mitchell	Limestone	Magnesian limestone
62	do	do	J. Hamilton	do	do
63	4½ miles north of Urbana	Champaign	D. W. Happersett	do	Bituminous dolomite
64	2 miles west of Springfield	Clarke	W. S. Thompson	do	Dolomite
65	do	do	A. Reinert	do	do
66	2 miles west of Springfield	Clarke	A. L. Eppley	Limestone	Dolomite
67	4 miles west of Springfield	do	Mrs. E. Moores	do	Arenaceous dolomite
68	do	do	A. Holcomb	do	do
69	2 miles west of Springfield	do	Robert Montes	do	do
70	1½ miles west of Springfield	do	James Mowatt	do	do
71	1 mile west of Springfield	Clarke	George Sintz	Limestone	Arenaceous dolomite
72	North edge of Springfield	do	Pittock & Bio	do	do
73	do	do	George H. Frey	do	do
74	3 miles west of Columbus	Franklin	Wilcox Bros	do	Limestone
75	4 miles northwest of Columbus	do	M. M. Williams	do	do
76	4 miles northwest of Columbus	Franklin	M. D. Slyh	Limestone	Limestone
77	do	do	Peter Burns	do	do
78	3 miles west of Columbus	do	Andrew McNinck	do	do
79	do	do	Lilley & Poston	do	do
80	4 miles west of Columbus	do	T. J. Price & Co	do	do
81	4 miles northwest of Columbus	Franklin	Smith & Price	Limestone	Limestone
82	Newtonville	Muskingum	T. B. Townsend	do	do
83	½ mile southwest of Zanesville	do	Philip Moran	do	do
84	Rockville	Fayette	I. N. Bonum	do	Bituminous dolomite
85	Yellow Springs	Greene	W. Stonfe	do	Argillaceous dolomite
86	4½ miles east of Xenia	Greene	Boots & Bickette	Limestone	Magnesian limestone
87	4 miles southeast of Xenia	do	W. McDonald	do	do
88	6 miles east of Dayton	do	John Archer	do	do
89	8 miles east of Dayton	do	H. Huston	do	do
90	1½ miles southeast of Dayton	Montgomery	Bullman Stone Company	do	do
91	1½ miles southeast of Dayton	Montgomery	D. Renner	Limestone	Magnesian limestone
92	do	do	C. Lanyon	do	do
93	do	do	M. Bosler	do	do
94	1½ miles southeast of Dayton	do	S. Lanyon	do	do
95	7½ miles north of Dayton	do	J. S. Booker	do	do
96	1 mile east of Lewisburg	Preble	C. Dishler	Limestone	Arenaceous dolomite
97	1 mile northwest of Euphemia	do	I. J. Weaver	do	Dolomite
98	do	do	R. Swisher	do	do
99	do	do	Bowman & Thompson	do	do
100	New Paris	do	T. J. Smith	do	Arenaceous magnesian limestone
101	New Paris	Preble	Sam. Smith & Co	Limestone	Arenaceous magnesian limestone
102	3 miles northeast of Eaton	do	Young & Christman	do	Dolomite
103	5½ miles northeast of Eaton	do	John O. Deem	do	do
104	At Hamilton	Butler	Kilfoyle & Joyce	do	Limestone
105	3 miles northeast of Hamilton	do	R. Andrews	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

OHIO—LIMESTONE—Continued.

Color.	STRUCTURE.			GEOLOGICAL AGE OF FORMATION.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Dark drab	Compact and vesicular	Even and parallel	Even, medium thick	Upper Silurian	Helderberg (water-lime).	1854	31
Light gray	Semi-crystalline, vesicular	Even, parallel, and massive.	Uneven, medium thick	do	do	1876	32
Drab	Vesicular	Even, wavy, and irregular.	Uneven, thin	do	do	1878	33
do	do	Irregular	Uneven, thin and broken	do	do	1868	34
Drab and blue-black	Compact and vesicular	Massive, irregular, and even.	Even, thin to medium	do	do	1840	35
Drab	Compact and vesicular	Massive, irregular, and even.	Even, thin to medium	Upper Silurian	Helderberg (water-lime).	1877	36
Dark drab	Compact and porphyritic	Wavy and irregular	Even and thin	do	do	1880	37
do	do	do	do	do	do	1878	38
Bluish gray	Fine and compact	Massive	Even, thin to medium	Devonian	Corniferous	1840	39
Gray and bluish gray	do	do	Even, medium thick	do	do	1878	40
Gray and bluish gray	Fine and compact	Massive	Even, medium thick	Devonian	Corniferous	1877	41
do	do	do	do	do	do	1845	42
do	do	do	do	do	do	1878	43
do	do	do	do	do	do	1835	44
do	Compact	do	do	do	do	1860	45
Drab	Vesicular	Wavy and irregular	Even and thin	Upper Silurian	Helderberg (water-lime).	1855	46
Gray	Porous	Massive	Even, medium thick	Devonian	Corniferous	1877	47
do	do	do	do	do	do	1830	48
Drab	Vesicular	Wavy and irregular	Even, medium thick	Upper Silurian	Niagara (Guelf)	1869	49
do	do	Irregular	do	do	do	1851	50
Drab	Vesicular	Irregular	Even, medium thick	Upper Silurian	Niagara (Guelf)	1830	51
do	do	do	do	do	do	1870	52
do	do	do	do	do	do	1856	53
do	do	do	do	do	do	1865	54
do	do	do	do	do	do	1856	55
Drab	Vesicular	Irregular	Even, medium thick	Upper Silurian	Niagara (Guelf)	1868	56
do	do	do	do	do	do	1874	57
do	Semi-crystalline	Wavy and irregular	do	do	do	1858	58
do	do	do	do	do	do	1874	59
do	do	do	do	do	do	1868	60
Drab	Semi-crystalline	Wavy and irregular	Even, medium thick	Upper Silurian	Niagara (Guelf)	1851	61
do	do	do	do	do	do	1851	62
Light drab	Vesicular	Irregular	Even and uneven, medium thick.	do	Helderberg (water-lime).	1802	63
Drab	do	Wavy and irregular	Even, medium thick	do	Niagara	1840	64
do	do	do	do	do	do	1876	65
Drab	Vesicular	Wavy and irregular	Even, medium thick	Upper Silurian	Niagara	1873	66
do	do	do	do	do	do	1862	67
Light drab	do	Irregular	do	do	do	1865	68
do	do	do	do	do	do	1860	69
do	do	do	do	do	do	1850	70
Light drab	Vesicular	Irregular	Even, medium thick	Upper Silurian	Niagara	1870	71
Drab	do	Wavy and irregular	do	do	do	1868	72
do	do	do	do	do	do	1840	73
Gray	Semi-crystalline, fossiliferous.	Irregular	Even, thick, and medium	Devonian	Corniferous	1881	74
do	do	do	do	do	do	1860	75
Gray	Semi-crystalline, fossiliferous	Irregular	Even, thick, and medium	Devonian	Corniferous	1840	76
do	do	do	do	do	do	1860	77
do	do	do	do	do	do	1870	78
do	do	do	do	do	do	1880	79
do	do	do	do	do	do	1858	80
Gray	Semi-crystalline, fossiliferous.	Irregular	Even, thick, and medium	Devonian	Corniferous	1872	81
Drab	Fine, semi-crystalline	Massive	Even, thin to medium	Sub-Carboniferous	Maxville limestone.	1874	82
Blue-black	Compact and fossiliferous	do	One 3-foot stratum	Carboniferous	Lower Coal Measures.	1875	83
Drab	Vesicular	Irregular	Even and thin	Upper Silurian	Helderberg (water-lime).	1866	84
Drab and light drab	do	do	Even, variable, thick	do	Niagara	1864	85
Drab	Semi-crystalline	Irregular	Even, medium thick	Upper Silurian	Niagara	1840	86
do	do	do	do	do	do	1825	87
do	do	do	do	do	do	1870	88
do	do	do	do	do	do	1875	89
do	do	do	do	do	do	1861	90
Drab	Semi-crystalline	Irregular	Even, medium thick	Upper Silurian	Niagara	1845	91
do	do	do	do	do	do	1851	92
do	do	do	do	do	do	1873	93
do	do	do	do	do	do	1866	94
do	do	do	do	do	do	1871	95
Drab	Compact and vesicular	Irregular	Even, thin to medium	Upper Silurian	Niagara	1860	96
do	do	do	do	do	do	1869	97
do	do	do	Even, medium thick	do	do	1850	98
do	do	do	do	do	do	1840	99
do	Porphyritic	Wavy and irregular	Even, thin to medium	do	do	1840	100
Drab	Porphyritic	Wavy and irregular	Even, medium thick	Upper Silurian	Niagara	1840	101
do	Semi-crystalline	do	do	do	do	1850	102
do	do	do	do	do	do	1855	103
Blue	Semi-crystalline, highly fossiliferous.	Irregular	do	Lower Silurian	Cincinnati	1865	104
do	do	do	do	do	do	1874	105

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

OHIO—LIMESTONE—Continued.

	Location of quarry	County	Name of the corporation, company, or individual	SPECIFIC VARIETY OF STONE	
				Popular name.	Scientific name.
106	5 miles east of Hamilton	Butler	J. Rupp	Limestone	Limestone
107	1½ miles southwest of Lambertion	Clinton	W. E. Oglesbee	do	Magnesian limestone
108	Greenfield	Ross	G. I. Rucker & Son	do	Bituminous dolomite
109	do	Highland	do	do	do
110	do	do	McAlun & Co	do	do
111	2 miles south of Lexington	Highland	Mrs. L. Dunn	Limestone	Bituminous dolomite
112	do	do	A. Carrill	do	do
113	Point Pleasant	Clermont	J. Delaney	do	Limestone
114	Cincinnati	Hamilton	F. Tearing	do	do
115	do	do	L. Grover	do	do
116	Cincinnati	Hamilton	J. Delaney	Limestone	Limestone
117	do	do	L. Butterbey	do	do
118	do	do	J. Cinck	do	do
119	do	do	E. Howe	do	do

INDIANA—MARBLE AND LIMESTONE.

1	Decatur	Adams	B. P. Rice	Limestone	Dolomite
2	Bluffton	Wells	Knipp & Gardner	do	do
3	Wabash	Wabash	Longs & Scott	do	Limestone
4	do	do	Hubbard & Smith	do	do
5	do	do	Pitzer Hipskin	do	do
6	Wabash	Wabash	William J. Ford	Limestone	Limestone
7	do	do	Mochering & Paul	do	Dolomite
8	do	do	Lillo & Shoemaker	do	Limestone
9	Logansport	Cass	Lux & Lux	do	Limestone and dolomite
10	do	do	J. E. Barnes	do	
11	Logansport	Cass	August Gleitz	Limestone	
12	3½ miles southwest of Kokomo	Howard	J. V. Smith	do	Magnesian limestone
13	Kokomo	do	George W. Defenbaugh	do	Limestone
14	Marion	Grant	D. R. McKinney	do	Magnesian limestone
15	do	do	Silvester Funkhouser	do	do
16	Marion	Grant	John Murphy	Limestone	Magnesian limestone
17	Montpelier	Blackford	William Twibell	do	Dolomite
18	Eaton	Delaware	George W. Carter	do	do
19	do	do	Bosman Brothers	do	do
20	Yorktown	do	L. D. Koontz	do	do
21	Anderson	Madison	William Crim	Limestone	Magnesian limestone
22	do	do	J. W. Sansberry	do	do
23	Greencastle	Putnam	Patrick Ash	do	Limestone
24	2 miles southwest of Greencastle	do	William Steeps	do	do
25	do	do	A. J. Crawford	do	do
26	2 miles southwest of Greencastle	Putnam	Vandalia Railroad Company	Limestone	Limestone
27	Oakdale	do	Moss & Hills	do	do
28	do	do	Torr & Brother	do	do
29	Putnamville	do	James Le	do	Siliceous limestone
30	Longwood	Fayette	Wilson Ball	do	Ferruginous dolomite
31	Longwood	Fayette	R. H. Moffitt	Limestone	Ferruginous dolomite
32	2½ miles northwest of Laurel, Franklin county.	do	H. Reese	do	Dolomite
33	2½ miles west of Laurel	Franklin	M. E. Secrest	do	do
34	2½ miles west of Laurel	do	John McGlin	do	do
35	3 miles southwest of Laurel	do	A. Cloud	do	do
36	3 miles south of Laurel	Franklin	J. A. Thomas	Limestone	Dolomite
37	New Point	Decatur	W. W. Hollengshe	do	do
38	5 miles southwest of Greensburg	do	Greensburg Limestone Company	do	do
39	Saint Paul	do	W. W. Lowe	do	do
40	do	do	J. L. Scanlan	do	do
41	2 miles west of Saint Paul	Shelby	G. W. McNeely	Limestone	Dolomite
42	Ellettsville	Monroe	John Matthews & Sons	do	Bituminous limestone
43	do	do	Perry Brothers	do	do
44	Stinesville	do	W. H. McHenry	do	do
45	do	do	McHenry & Brother	do	do
46	Stinesville	Monroe	Davis & Cassner	Limestone	Bituminous limestone
47	Spencer	Owen	B. Schweitzer	do	Limestone
48	3½ miles northeast of Spencer	do	Simpson & Archer	do	Bituminous limestone
49	do	do	E. R. Bladen	do	do
50	do	do	Howard & Deng	do	do
51	5 miles west of Bedford	Lawrence	N. C. Hinsdale & Co	Limestone	Limestone
52	4½ miles west of Bedford	do	Voris, Rodgers & Co	do	do
53	Bedford	do	Chicago-Bedford Stone Company	do	do
54	do	do	Fillion & Smith	do	do
55	Lawrenceport	do	A. F. Berry	do	do
56	Fort Ritner	Jackson	E. B. Dixon	Limestone	Bituminous limestone
57	3½ miles north of North Vernon	Jennings	Hicks & Holmes	do	Limestone
58	North Vernon	do	P. Conklin & Co	do	do
59	3 miles south of North Vernon	do	H. C. Hettman	do	do
60	Oakdale	do	Hicks & Holmes	do	Magnesian limestone

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

OHIO—Limestone—Continued.

Color.	Structure. Texture.	Stratification.	Jointing, bedding, or natural surface.	Geological age of formation. Period.	Epoch.	Year in which opened.	
Blue	Semi-crystalline, highly fossiliferous.	Irregular	Even, medium thick	Lower Silurian	Cincinnati	1850	106
Drab	Semi-crystalline	Wavy	do	Upper Silurian	Niagara	1850	107
do	Compact and vesicular	Even and massive	Very even, thin to medium	do	Helderberg (water lime).	1850	108
do	do	do	do	do	do	1850	109
do	do	do	do	do	do	1840	110
Drab	Vesicular	Even and parallel	Even, medium thick	Upper Silurian	Niagara	1850	111
do	do	do	do	do	do	1875	112
Blue	Semi-crystalline, fossiliferous.	Irregular	Even, thin to medium	Lower Silurian	Cincinnati	1876	113
do	do	do	do	do	do	1850	114
do	do	do	do	do	do	1860	115
Blue	Semi-crystalline, fossiliferous.	Irregular	Even, thin to medium	Lower Silurian	Cincinnati	1867	116
do	do	do	do	do	do	1861	117
do	do	do	do	do	do	1864	118
do	do	do	do	do	do	1868	119

INDIANA—Marble and Limestone.

Drab	Compact and vesicular	Even and parallel	Thin to medium	Upper Silurian		1876	1
do	Finely vesicular	Massive	Even and medium thick	do		1877	2
do	Semi-crystalline	Wavy and irregular	Even and thin	do		1866	3
do	do	do	do	do		1876	4
do	do	do	do	do		1878	5
Drab	Semi-crystalline	Wavy and irregular	Even and thin	Upper Silurian		1873	6
do	Vesicular	Irregular	Even, medium thick	do		1866	7
do	do	do	Uneven and thin	do		1873	8
do	Semi-crystalline	Massive	Uneven, medium thick	do		1872	9
Gray	Fine and compact	Even and massive	Even, medium thick	do		1849	10
Gray	Fine and compact	Even and massive	Even, medium thick	Upper Silurian		1849	11
Drab	do	do	do	do		1876	12
do	Fine and compact (conchoidal fracture).	Even and indistinct	Even and thin	Devonian		1850	13
do	Semi-crystalline	Variable	do	Upper Silurian		1864	14
do	do	do	do	do		1864	15
Drab	Fine and compact	Variable	Even thin to medium	Upper Silurian		1867	16
do	Semi-crystalline	Irregular	do	do		1870	17
do	Semi-crystalline, vesicular	do	Even and thin	do		1855	18
do	do	do	do	do		1875	19
do	Vesicular	Variable	do	do		1835	20
Gray	Fine and compact	Even	Even, thin to medium	Upper Silurian		1840	21
do	do	do	do	do		1840	22
Drab	Semi-crystalline	Massive	Even, medium thick	Sub-Carboniferous		1869	23
do	do	do	do	do		1860	24
do	do	do	do	do		1870	25
Drab	Semi crystalline	Massive	Even medium thick	Sub-Carboniferous		1875	26
do	do	do	do	do		1875	27
do	do	do	do	do		1876	28
do	do	do	Even and thick	do		1865	29
Drab and buff	Vesicular	Wavy and massive	Even, medium thick	Upper Silurian		1862	30
Drab and buff	Vesicular	Wavy and massive	Even, medium thick	Upper Silurian		1870	31
Drab	Semi-crystalline	do	do	do		1877	32
do	do	do	do	do		1876	33
do	do	do	do	do		1860	34
do	do	do	do	do		1860	35
Drab	Semi-crystalline	Wavy and massive	Even, medium thick	Upper Silurian		1878	36
do	do	Massive	Even, thin to medium	do		1875	37
do	do	do	do	do		1850	38
do	do	do	Even, medium thick	do		1870	39
do	do	do	do	do		1860	40
Drab	Semi-crystalline	Massive	Even medium thick	Upper Silurian		1859	41
Gray and drab	Granular (oolitic)	do	Even and thick	Sub-Carboniferous		1867	42
do	do	do	do	do		1866	43
Gray	do	do	do	do		1878	44
do	do	do	do	do		1879	45
Gray	Granular (oolitic)	Massive	Even and thick	Sub-Carboniferous		1875	46
Drab	Fine and compact (conchoidal fracture).	do	Even, medium thick	do		1869	47
Gray	Granular (oolitic)	do	Even and thick	do		1870	48
do	do	do	do	do		1870	49
do	do	do	do	do		1878	50
Gray	Granular (oolitic)	Massive	Even and thick	Sub-Carboniferous		1879	51
do	do	do	do	do		1879	52
do	do	do	do	do		1876	53
do	do	do	do	do		1867	54
do	do	do	do	do		1879	55
Gray	Granular (oolitic)	Even and parallel	Even and thick	Sub-Carboniferous		1860	56
Drab	Semi-crystalline	Massive	Even, medium thick	Upper Silurian		1875	57
do	do	Irregular	do	do		1873	58
do	do	do	do	do		1850	59
do	do	Massive	do	do		1876	60

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

INDIANA—MARBLE AND LIMESTONE—Continued.

	Location of quarry	County.	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
61	Osgood	Ripley	Peter Wagner	Limestone	Magnesian limestone
62	do	do	Ashman & Glasgow	do	do
63	Sheam	Washington	Emanuel Zink	do	Limestone
64	3 miles west of New Albany	Floyd	Christian Haller	do	do
65	do	do	N Bettinger	do	do

INDIANA—SANDSTONE.

1	Williamsport	Warren	B F Gregory estate	Sandstone	Sandstone
2	Attica	do	S Barnhart	do	do
3	French Lick	Orange	W F Osborne	do	do
4	do	do	T N Braxtun	do	do
5	3 miles east of Connellton	Perry	A Hallabach	do	do

ILLINOIS—LIMESTONE.

1	300 yards south of Roseclair	Hardin	W W Wright	Limestone	Magnesian and bituminous limestone
2	1¼ miles above Roseclair	do	C Howard & Sons	do	
3	2 miles from Roseclair, Jacks Point	do	Gus A Crangen	do	Limestone
4	2 miles east of Roseclair, Shetlerville	do	do	do	
5	Cresote village	Randolph	John Hertz	do	Limestone
6	1 mile north of Chester village	Randolph	Southern Illinois penitentiary	Limestone	Limestone
7	2 miles north of Chester village	do	John Hertz	do	do
8	City of Belleville	Saint Clair	O F Lorenzen	do	
9	do	do	Zeph Kern	do	
10	1 mile east of Columbia	Monroe	Peter Friedrich & Son	do	Limestone
11	6 miles north of Bruce station	Clinton	Joseph Fowler	Limestone	Siliceous magnesian limestone
12	Selma	Madison	Stephen Ingold	Black lime	Calcareous dolomite
13	1 mile below Grafton	Jersey	Grafton Quarry Company	Limestone	
14	City of Quincy	Adams	I W Modock	do	
15	City of Kankakee	Kankakee	Lawler & Orr	do	
16	City of Kankakee	Kankakee	Kankakee Stone and Lime Company	Limestone	Dolomite
17	1½ miles southwest of Lemont	Will	Excelsior Stone Company	do	do
18	1½ miles northeast of Joliet	do	J & J Stone Company	do	do
19	2 miles east of central of Joliet	do	T C Hart & Co	do	
20	5th ward, Joliet	do	Charles Wetzel	do	Dolomite
21	3d ward, Joliet	Will	Simon Hansset	Limestone	
22	West side of Joliet	do	J Wetzel & Co	do	
23	do	do	Joseph Wagner	do	
24	½ mile east from C H, Joliet	do	Dickinson Bros	do	Dolomite
25	Lime Cross station, Joliet	do	Joliet Stone Company	do	do
26	2½ miles north of Joliet	Will	Isaac Nolen	Limestone	Dolomite
27	North of Joliet	do	Wilhelm Kramer	do	do
28	do	do	Peter Co	do	do
29	2½ miles south of Joliet	do	Sargent & Morell	do	do
30	1 mile east of Lemont	Cook	Chicago and Lemont Stone Company	do	do
31	1½ miles east of Lemont	Cook	Illinois Stone Company	Limestone	Dolomite
32	½ mile northeast of Lemont	do	The Singer Lead Company	do	do
33	Village of Lemont	do	Chicago and Lemont Stone Company	do	do
34	¼ mile south west of Lemont	do	Edinger & Bodenschatz	do	do
35	¼ mile southwest of Lemont	do	Singer & Talcott	do	do
36	City of Batavia	Kane	F F Brady	Limestone	
37	do	do	O P Barker & Son	do	
38	City of Aurora	do	Anthon Berthelet	do	Dolomite

ILLINOIS—SANDSTONE.

1	Golconda	Pope	C M Cole	Sandstone	Sandstone
2	Chester	Randolph	Southern Illinois penitentiary	do	do
3	2½ miles from Pinckneyville	Perry	John D Day	White sandstone	do
4	Xenia	Clay	William Haug	Sandstone	do
5	Mississippi river, 4 miles up Hop Hollow.	Madison	J W Crawford	do	do

MICHIGAN—LIMESTONE.

1	2½ miles southeast of Raisinville	Monroe	Fritz Rath	Limestone	
2	2½ miles from Raisinville	do	John Knaggs	do	
3	Dundee	do	Nagor & Bemis	do	
4	Sibley's station	Wayne	F. Sibley	do	
5	Alpena	Alpena	Owen Fox	White and blue limestone.	

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

INDIANA—Marble and Limestone—Continued.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Drab	Semi-crystalline	Wavy and massive	Even, thin	Upper Silurian		1871	61
do	do	do	do	do		1874	62
Gray	Granular (oolitic)	Massive	Even and thick	Sub-Carboniferous		1861	63
do	do	do	do	do		1840	64
do	do	do	do	do		1850	65

INDIANA—Sandstone.

Gray	Coarse	Coarse and massive	Even and thick	Carboniferous	Conglomerate	1860	1
Gray and bluish gray	do	do	do	do	do	1873	2
Gray	Fine and medium	Even, fine and coarse	Even, medium thick	Sub Carboniferous		1850	3
do	do	do	do	do		1830	4
Light brown	Medium	Irregular	Even, one 30-foot stratum	Carboniferous		1871	5

ILLINOIS—Limestone.

Drab	Fine, compact, partly oolitic	Variable	Even, medium	Sub-Carboniferous		1867	1
Light gray	Medium, compact	Massive	Even, thick	do		1877	2
Drab	Fine, compact	do	do	do		1878	3
Dark drab	Medium, fossiliferous	do	Even, thin to thick	do		1880	4
do	Fine, fossiliferous	do	Uneven, thin to thick	do		1880	5
Drab	Fine, fossiliferous	Variable	Medium to thick	Sub-Carboniferous		1877	6
do	do	Massive	Even, thin to medium	do		1877	7
Light drab	Fine, compact	Indistinctly laminated	Irregular, thin to medium	do		1874	8
Drab	Medium, compact	Massive	Even, thin to medium	do		1873	9
Gray	Medium, crystalline	do	Even, thick	do		1856	10
Gray	Fine, fossiliferous	Massive	Even, thin to medium	Sub-Carboniferous		1879	11
Dark gray	Medium, fossiliferous	do	Even, thick	do		1867	12
Gray	Variable	do	Even, medium	Upper Silurian		1859	13
do	Variable, crystalline	do	Thin to medium	Devonian		1874	14
Light drab	Medium, vesicular	do	Even, thick	Upper Silurian		1867	15
Light drab	Medium, vesicular	Massive	Medium to thick	Upper Silurian		1855	16
do	Fine, compact	Indistinctly laminated	Even, thick	do		1867	17
do	Compact	do	do	do		1874	18
Drab	do	do	do	do		1880	19
Light drab	Fine, compact	do	Even, thin to thick	do		1871	20
Light drab	Fine, vesicular	Indistinctly laminated	Even, thin to thick	Upper Silurian		1856	21
do	Fine, compact	do	Thin to thick	do		1867	22
do	do	do	Medium to thick	do		1884	23
Drab	do	do	Even, thin to thick	do		1853	24
Light drab	do	do	Even, thin to medium	do		1874	25
Drab	Fine, compact	Indistinctly laminated	Even, thin to thick	Upper Silurian		1855	26
do	do	do	do	do		1852	27
do	do	do	do	do		1852	28
Light drab	do	do	do	do		1866	29
do	do	do	do	do		1854	30
Light drab	Fine, compact	Indistinctly laminated	Even, thin to thick	Upper Silurian		1852	31
do	do	do	Even, medium to thick	do		1854	32
do	do	do	do	do		1878	33
do	do	do	do	do		1869	34
Drab	do	do	Even, thin to thick	do		1869	35
Drab	Variable	Massive	Even, thin to thick	Upper Silurian		1872	36
do	Fine, compact	do	do	do		1848	37
Light drab	Medium, compact, and vesicular.	do	Even, medium to thick	do		1848	38

ILLINOIS—Sandstone.

Buff	Coarse	Massive	Even, thick	Sub-Carboniferous		1879	1
do	Fine, compact	Irregular	Even, thin to thick	do		1878	2
Gray	Medium, compact	Massive	Even, thick	Carboniferous		1866	3
do	Compact	Indistinctly laminated	do	do		1873	4
Drab	Medium, compact	Massive	do	Sub-Carboniferous		1876	5

MICHIGAN—Limestone.

Drab	Medium, compact, semi-crystalline.	Massive	Even, thin to thick	Devonian		1880	1
do	Fine, compact	do	do	do		1880	2
Gray	Fine, fossiliferous	do	Uneven, thick	Upper Silurian			3
Light drab	do	do	Even, thick	Devonian		1824	4
Gray	Medium	do	Even, thin to thick	do		1879	5

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

MICHIGAN—SANDSTONE.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
1	Lu'a	Monroe	Henry McCarthy	Sandstone	
2	Stony Point	Jackson	Michigan Stone Company	do	
3	Lyon township	Ionia	C S Marsh & Co	do	
4	do	do	W E Avery & Co	do	
5	Marquette	Marquette	Watson & Pollard	do	

WISCONSIN—SANDSTONE.

1	3 miles west of Waukesha	Dane	Consolidated Wisconsin Granite Quarrying Company	Sandstone	
2	Madison, 3 miles from capitol building	do	David Streets	do	
3	Madison, 3 miles west of capitol building	do	August Pennack	do	
4	Madison	do	Fred Stuckey	Calciferous sandstone	
5	Alderney	Sauk	Chicago and Northwestern Railway Co	Sandstone	
6	Manitou	Juneau	C W Potter	Sandstone	
7	do	do	H V Pratt	do	
8	7 miles southwest of Alma	Buffalo	Red Sandstone Company	do	
9	4 miles south of Grand Rapids	Wood	J Livingston	do	
10	Pittsville	Portage	Mrs E J Bacon	do	
11	Stevens Point	Portage	J A Avery	Sandstone	
12	do	do	A D Sage	do	

a This quarry was considered of sufficient importance to tabulate, though opened in 1881.

WISCONSIN—LIMESTONE.

1	2 miles west of center of Racine	Racine	C Box & Son	Limestone	Dolomite
2	do	do	William Beswick	do	
3	1 mile west of C. H., Janesville	Rock	Andrew Byron	do	
4	2 miles west of C. H., Janesville city.	do	Cornelius Stout	do	
5	3 miles north west of Beloit	do	Samuel Cross	do	
6	1 mile east of Westport	Dane	William Veerhusen	Limestone	
7	7 miles north of Mendota.	do	P. O'Malley	do	
8	3 miles west of Madison	do	Andrew Bernard	Magnesian limestone	Magnesian limestone
9	Waukesha	Waukesha	Rockwell & Co	Limestone	Dolomite
10	Bridge Milwaukee	Milwaukee	A. J. Marigold & Bro	do	
11	Waukesha	Milwaukee	State Bank	Limestone	
12	Kellis station	do	Schweigert & Marigold	do	
13	3 miles northwest of Watertown.	Dodge	Richard Perry	do	
14	[illegible]	La Crosse	Hugh Wright	do	
15	do	do	Leopold Lamet	do	
16	1 mile west by south of La Crosse	La Crosse	Richard Waggoner	Limestone	
17	1 mile west of La Crosse	do	John Nelson	do	Dolomite
18	3 miles south of east of La Crosse	do	Magnus Nelson	do	do
19	2 miles west of La Crosse	do	Roydl Roydl	do	do
20	7 miles southeast of Fond du Lac	Fond du Lac	Nast Bros & Co	do	Dolomite
21	7 miles southeast of Fond du Lac	Fond du Lac	Marblehead Lime Company	Limestone	Dolomite
22	3 miles southeast of Fond du Lac	do	James Sylvester	do	do
23	4 miles southeast of Fond du Lac	do	Matthew V. Butler	do	do
24	Between 1 and 2 miles south of Fond du Lac	do	S Sylvester	do	do
25	Between 2 and 3 miles from Fond du Lac	do	S Sylvester jr	do	do
26	2½ miles northeast from Oak Centre	Fond du Lac	C E Town	Limestone	
27	6 miles from Fond du Lac	do	Christian Geiger	do	Dolomite
28	Waupun	do	John McCune	do	do
29	2 miles northwest of Sheboygan	Sheboygan	H E Roth	do	do
30	Sheboygan Falls	do	Kelhagen Bros	do	do
31	6 miles west of north of Manitowoc	Manitowoc	Lewis Miller & Co	Limestone	Dolomite
32	Menasha	Winnebago	Oswald J. Holly	do	
33	Neenah	do	Charles Gerhardt	do	
34	do	do	Patrick Mowrath	do	Dolomite
35	do	do	T. F. Moulton	do	
36	2 miles southwest of center of Oshkosh	Winnebago	Schreider & Frank	Limestone	Dolomite
37	Oshkosh	do	Frank Last	do	do
38	Rivers Falls	Pierce	Thomas Walker	do	do
39	North side of Fountain City	Buffalo	Richtman & Kerckner & Mattansch	Sandy limestone	do
40	Alma	do	Matthias Braun	do	
41	Kaukauna	Outagamie	United States Government	Limestone	Dolomite
42	Lydard village	do	Kaukauna Water Power Company	do	do
43	Appleton	do	Waters & Green	do	
44	4 miles south of C. H., Appleton	do	Y. B. Waters	do	
45	Hortonville	do	H. W. Thompson	do	
46	Duck Creek station	Brown	Manuel Bannette	Limestone	Dolomite
47	do	do	Chicago and Northwestern Railway Co	do	do
48	6 miles east of Hudson	Saint Croix	Henry Gibson	do	

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

MICHIGAN—SANDSTONE.

Color.	STRUCTURE.			GEOLOGICAL AGE OF FORMATION.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Buff	Medium, compact, uniform	Massive	Medium to thick	Devonian		1876	1
....do	Medium	....do	Even, thick	Sub Carboniferous		1870	2
				Carboniferous		1865	3
				....do		1870	4
Brown	Medium, uniform	Massive	Thin to thick	Lower Silurian		1871	5

WISCONSIN—SANDSTONE.

Light gray	Fine	Massive	Uneven, thick	Archæan		1881	1
Buff	....do	....do	Thin to thick	Lower Silurian		1858	2
....do	Fine, compact	....do	Even, thick	....do		1876	3
....do	Coarse	....do	Even, medium to thick	....do		1850	4
Light pink	Fine, compact	Indistinct	Even, thick	....do		1880	5
Light gray	Fine, compact	Indistinct	Even, thin to thick	Lower Silurian		1880	6
....do	....do	....do	....do	....do		1874	7
Buff	Medium to coarse	Massive	Even, thin to medium	....do		1879	8
Light gray	Compact	Indistinctly laminated	Uneven, thin to thick	....do		1874	9
....do	Medium	Irregular	Even, thin to medium	....do		1878	10
Light gray	Medium	Irregular	Even, thin to thick	Lower Silurian		1872	11
....do	....do	....do	....do	....do		1879	12

WISCONSIN—LIMESTONE.

Drab	Variable, vesicular	Massive	Even, thin to medium	Upper Silurian		1879	1
....do	....do	....do	....do	....do		1850	2
....do	Medium, vesicular	....do	Variable, thin to thick	Lower Silurian		1840	3
....do	....do	....do	Even, thin to thick	....do		1878	4
....do	Coarse, variable	....do	Uneven, thin to thick	....do		1860	5
Buff	Medium, compact	Massive	Medium to thick	Lower Silurian		1877	6
Light buff	Fine, compact	....do	Variable, thin to thick	....do		1869	7
Buff	Variable	....do	Even, medium to thick	....do		1855	8
Drab	Fine, compact	....do	....do	Upper Silurian		1871	9
....do	Variable	....do	Even, thin to thick	....do		1873	10
Drab	Variable	Massive	Even, thin to thick	Upper Silurian		1876	11
....do	Coarse	....do	....do	....do		1845	12
....do	Variable	....do	Even, medium to thick	Lower Silurian		1878	13
Light drab	....do	Even parallel	Even, medium to thin	....do		1877	14
....do	....do	Irregular	Uneven, medium to thin	....do		1880	15
Light drab	Variable	Irregular	Even, medium to thin	Lower Silurian		1879	16
....do	....do	....do	Even, medium	....do		1880	17
....do	....do	Even, parallel	Even, thin to medium	....do		1872	18
....do	....do	....do	....do	....do		1870	19
....do	....do	....do	Uneven, thin to medium	Upper Silurian		1855	20
Light drab	Variable	Even, parallel	Even, thin to medium	Upper Silurian		1880	21
....do	Fine, compact	....do	....do	....do		1850	22
....do	....do	....do	....do	....do		1878	23
....do	....do	....do	....do	....do		1864	24
....do	....do	....do	Thin to medium	....do		1864	25
Drab	Medium to fine	Massive	Even, thin to medium	Upper Silurian		1878	26
....do	Fine, compact	Even parallel	....do	....do		1863	27
....do	Fine, vesicular	....do	....do	....do		1850	28
Light drab	Fine, crystalline	Massive	Even, thin to thick	....do		1854	29
....do	....do	Indistinct	....do	....do		1879	30
Drab	Fine, compact	Massive	Uneven, thin to medium	Upper Silurian		1868	31
....do	Medium, crystalline	Irregular	Uneven, thin to thick	Lower Silurian		1876	32
....do	Coarse	....do	Uneven, thin	....do		1876	33
....do	....do	....do	....do	....do		1877	34
....do	....do	....do	Uneven, thin to medium	....do		1857	35
Drab	Medium	Indistinct	Even, thin to thick	Lower Silurian		1864	36
....do	....do	....do	Even, medium to thick	....do		1857	37
Drab and buff	Medium, vesicular	Variable	Even, thin to medium	....do		1871	38
Light gray	....do	Massive	Even, medium	....do		1880	39
Gray	....do	....do	....do	....do		1877	40
Drab	Medium, vesicular	Irregular	Even, medium to thick	Lower Silurian		1867	41
....do	Fine, porphyritic	....do	....do	....do		1878	42
....do	Variable	Massive	Uneven, thin to thick	....do		1880	43
....do	....do	Irregular	Uneven, thin to medium	....do		1880	44
....do	Fine, compact	Massive	Even, thin to medium	....do		1879	45
Drab	Fine, porphyritic	Irregular	Even, thick	Lower Silurian		1857	46
....do	....do	....do	....do	....do		1879	47
....do	Medium, fossiliferous	Massive	Even, medium to thick	....do		1879	48

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

MINNESOTA—CRYSTALLINE SILICEOUS ROCKS.

	Location of quarry	County.	Name of the corporation, company, or individual.	SPECIFIC VARIETY OF STONE.	
				Popular name.	Scientific name.
1	Sauk Rapids	Benton	G. S. Reeder	Granite	Hornblende biotite granite
2	East Saint Cloud	Sherburne	Breed & Young	do	Hornblende granite
3	Taylors Falls	Chisago	Minneapolis and Saint Louis Railroad Co.	Trap	Olivine diabase

MINNESOTA—MARBLE AND LIMESTONE.

1	Stillwater	Washington	David Prescott	Limestone	Siliceous dolomite and dolomite
2	do	do	D. Donahue	do	do
3	do	do	Ed Mahoney	do	Siliceous dolomite
4	do	do	John Conkling	do	Siliceous dolomite and dolomite
5	Saint Paul	Ramsey	M. Rocke	do	Magnesian limestone
6	Saint Paul	Ramsey	William Zollman	Limestone	Magnesian limestone
7	do	do	William Dawson, lessor	do	do
8	do	do	Berg & Young	do	do
9	do	do	A. Ostrander	do	do
10	do	do	William Dawson, lessor	do	do
11	Saint Paul	Ramsey	William Dawson, lessor	Limestone	Siliceous magnesian limestone
12	West Saint Paul	do	Adam Rau	do	Magnesian limestone
13	Minneapolis	Hennepin	W. W. Eastman	do	do
14	do	do	Franklin Cook	do	do
15	do	do	Ole Dale	do	do
16	Minneapolis	Hennepin	Charles Sandhoff	Limestone	Magnesian limestone
17	do	do	Weeks & Holscher	do	do
18	do	do	James Bayer	do	Magnesian limestone and siliceous dolomite.
19	do	do	Foley & Herbert	do	do
20	Red Wing	Goodhue	G. A. Carlson	do	Dolomite
21	Red Wing	Goodhue	R. S. Buckland	Limestone	Dolomite
22	Lawrence	do	Lostetter & Co.	do	do
23	Cannon City	Rice	Phillip Cramer	do	Calcareous dolomite and limestone
24	Kasota	Le Sueur	J. W. Babcock	Sand-rock	Dolomite
25	do	do	Breen, Young & Co.	do	do
26	4 miles north of Mankato	Blue Earth	J. R. Beatty & Co.	Sand-rock	Dolomite
27	Mankato	do	O. R. Mather	do	do
28	do	do	J. H. Beatty	Limestone	do
29	Clinton Falls	Steele	Landesmith & Son	Lime-rock	Siliceous dolomite
30	Mantorville	Dodge	H. Hook, P. Mantor, A. Doig	Limestone	do
31	Stockton	Winona	Chicago and Northwestern Railroad Company.	Sand-rock	Dolomite
32	Winona	do	C. H. Potter	Limestone	do
33	do	do	John O'Dac	do	do

MINNESOTA—SANDSTONE.

1	Fond du Lac	Saint Louis	M. Boyle	Sand-rock	Sandstone
2	Huckleby	Pine	Saint Paul and Duluth Railroad	do	do
3	Jordan	Scott	Phillip Kipp	do	do
4	do	do	F. Nicolin	do	do
5	Courtland	Nicollet	Fritz Meyerding	Quartzite	Quartzite

IOWA—MARBLE AND LIMESTONE.

1	Lansing	Allamakee	City of Lansing	Limestone	Dolomite, siliceous
2	do	do	John Nelson	do	Dolomite
3	1 mile southeast of Waukon	do	Frank Sohn	do	do
4	¼ mile north of Decorah	Winneshiek	D. B. Ellsworth	do	Magnesian limestone
5	do	do	M. Steyer	do	do
6	1 mile south of Osage	Mitchell	David Armstrong	Limestone	Dolomite
7	½ mile northeast of Mason city	Cerro Gordo	Poyfeit & Son	do	Limestone
8	½ mile east of Mason city	do	A. F. Lien & Brother	do	Magnesian limestone
9	½ mile southeast of Mason city	do	J. L. Parker	do	Dolomite
10	¾ mile northwest of Marble Rock	Floyd	Boone Brothers	do	Limestone
11	3 mile southeast of Charles city	Floyd	J. S. Trigg	Limestone	Argillaceous-magnesian limestone
12	4 miles northeast of Clermont (Fayette county).	Clayton	E. H. Williams	do	Siliceous dolomite
13	McGregor	do	A. C. Boyle	do	
14	1 mile west of Bristow	Butler	E. Frick	do	Dolomite
15	Humboldt	Humboldt	C. A. Lonbeer	do	do
16	Humboldt	Humboldt	A. B. Snyder	Limestone	Dolomite
17	1 mile southeast of Dakota City	do	Miner & Howell	do	do
18	Fort Dodge	Webster	John Linebon	do	Magnesian limestone and dolomite
19	1½ miles west of Iowa Falls	Hardin	George W. Chapman	do	Dolomite
20	Iowa Falls	do	A. A. Wells & Son	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

MINNESOTA—Crystalline Siliceous Rocks.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Dark gray	Medium	Massive	Horizontal and vertical	Archæan		1870	1
Dark gray and red	Fine	do	Irregular	do		1868	2
Black	Medium	do (a)	do	Lower Silurian		1880	3

a Two other granites of a different structure and appearance quarried at this place.

MINNESOTA—Marble and Limestone.

Light buff	Medium, vesicular	Irregular	Even, thin to thick	Lower Silurian	Saint Lawrence	1854	1
do	do	do	Even, medium to thick	do	do	1854	2
do	do	do	do	do	do	1857	3
do	do	do	Even thin to medium	do	do	1847	4
Light blue	Fine, semi-crystalline	do	do	do	Trenton	1856	5
Light blue	Fine, semi-crystalline	Irregular	Even, thin to medium	Lower Silurian	Trenton	1856	6
do	do	do	do	do	do	1870	7
do	do	do	Even, thick	do	do	1856	8
do	do	do	Even, thin to medium	do	do	1870	9
do	do	do	Even, medium	do	do	1869	10
Light blue	Fine, semi-crystalline	Irregular	Even, thin to medium	Lower Silurian	Trenton	1858	11
do	do	do	Even, medium	do	do	1871	12
do	Fine, compact	Massive	Even, thick	do	do	1865	13
do	do	Irregular	Even, thin to medium	do	do	1870	14
Light blue and drab	do	Massive	Even, thin to thick	do	do	1879	15
Drab	Fine, compact	Irregular	Even, medium	Lower Silurian	Trenton	1876	16
Light blue	do	do	Even, medium to thick	do	do	1864	17
do	Fine, vesicular	Massive	Even, thin to thick	do	do	1878	18
do	do	Irregular, wavy	Thin to medium	do	do	1879	19
Buff	Fine, vesicular, & compact	Massive	Even, medium to thick	do	Saint Lawrence	1868	20
Light drab	Fine, vesicular, & compact	Massive	Even, thin to thick	Lower Silurian	Saint Lawrence	1868	21
Light gray	Medium, vesicular	do	Even, thick	do	do	1855	22
Drab	Fine, compact	do	Even, thin to thick	do	Trenton	1865	23
Buff	Semi-crystalline, vesicular	Irregular	Even, thick	do	Shakopee	1870	24
do	do	do	Even, thin to medium	do	do	1868	25
Buff	Semi-crystalline, vesicular	Irregular	Even, medium to thick	Lower Silurian	Shakopee	1879	26
do	do	do	Even, thin to thick	do	do	1853	27
do	Fine, semi-crystalline	do	Even, thin to medium	do	do	1854	28
Drab	Fine, compact	do	do	do	Hudson River	1868	29
Light buff	Variable, vesicular	do	Even, medium to thick	do	Galena	1856	30
Light drab	Fine, vesicular	Irregular	Even, thin to medium	Lower Silurian	Saint Lawrence	1876	31
Drab	do	do	Even, thin to thick	do	do	1870	32
do	do	do	Even, thick	do	do	1854	33

MINNESOTA—Sandstone.

Brown	Medium	Massive	Even, thin to thick	Lower Silurian	Potsdam	1870	1
Red	do	do	Even, medium	do	Saint Croix	1870	2
Light gray	Fine, friable	Irregular	Even, thin to medium	do	Jordan	1862	3
do	do	do	do	do	do	1858	4
Red	Fine, compact	Massive	Even, thin to thick	do	Potsdam	1857	5

IOWA—Marble and Limestone.

Light drab	Coarse	Massive	Even, medium thick	Lower Silurian	Potsdam	1880	1
do	Coarse, vesicular	do	do	do	Lower magnesian	1870	2
Mottled gray	Fine, homogeneous	do	Uneven, thin	do	Trenton	1880	3
do	Semi-crystalline, vesicular	Wavy, irregular	Even, thin to medium	do	do	1879	4
do	do	do	Even, medium thick	do	do	1860	5
Bluish gray, mottled, and buff	Fine, compact, porphyritic	Irregular	Even, medium thick	Devonian	Hamilton	1874	6
Light drab	do	Massive	do	do	do	1872	7
Drab and light drab mottled	Variable	Massive and irregular	do	do	do	1876	8
Drab with buff tint	Crystalline, compact, and vesicular	Irregular	do	do	do	1872	9
Dark drab and light buff	Semi-crystalline	Irregular and massive	Even, thick to medium	do	do	1875	10
Drab with buff patches	Semi-crystalline, fossiliferous	Irregular	Uneven thin to medium	Devonian	Hamilton	1874	11
Light buff	Vesicular	do	Even, thick to medium	Upper Silurian	Niagara	1854	12
do	Coarse, vesicular	Massive	Uneven, thick	Lower Silurian	Lower magnesian	1872	13
Drab and yellowish drab	Semi-crystalline, porphyritic	do	Even, medium thick	Devonian	Hamilton	1880	14
Drab mottled with buff	Fine, compact	Irregular	do	Sub-Carboniferous	Kinderhook	1870	15
Drab	Fine, semi-crystalline	Irregular	Uneven, thin	Sub-Carboniferous	Kinderhook	1870	16
Light brown, or olive and drab	Fine, compact	Massive	Even, thick to medium	do	do	1870	17
Drab	do	Irregular	Uneven, medium to thick	Carboniferous	Lower Coal Measures.	1868	18
Light brown	Porous	Massive	Even, thick	Sub-Carboniferous	Kinderhook	1865	19
do	Variable	do	Even, medium thick	do	do	1854	20

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

IOWA—MARBLE AND LIMESTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
21	1 mile southeast of Iowa Falls	Hardin	L. L. Kelly	Limestone	Limestone and dolomite
22	Conrad	Grundy	William T. Crealius	do	Limestone
23	1 mile northwest of Waterloo	Black Hawk	William Love	do	Siliceous dolomite
24	Cedar Falls	do	Falls Improvement	do	Dolomite
25	1 mile west of La Porte	do	G. A. Lowmaster	do	do
26	4 miles east of Independence	Buchanan	James Forrester	Limestone	Limestone
27	3 miles southeast of Manchester	Delaware	Charles A. & S. A. Davis	do	Dolomite
28	1 mile north of Farley	Dubuque	B. N. Arquette	do	do
29	1 mile east of Farley	do	C. E. De Ruse & Co	do	do
30	Dubuque	do	Martin & Sloane	do	do
31	do	Dubuque	Specht, Lee	Limestone	Dolomite
32	do	do	Joseph Berg	do	do
33	do	do	William Gelhaus	do	do
34	do	do	F. W. Kramer	do	do
35	New Sabula	Jackson	E. A. Woods	do	Ferruginous dolomite
36	4 miles east of Maquoketa	Jackson	A. Conrad	Limestone	Ferruginous dolomite
37	Maquoketa	do	Bluff Stone, Becker & Dunham	do	do
38	1 mile east of Hale	Jones	O. Brown	do	Bituminous dolomite
39	1 mile south of Hale	do	Solomon & J. N. Garrison and others	do	do
40	1½ miles southeast of Olin	do	A. Lockland	do	do
41	3½ miles southeast of Olin	Jones	J. Easterly	Limestone	Bituminous dolomite
42	do	do	William Gordon	do	do
43	1 mile northwest of Monticello	do	J. S. Fellet	do	Dolomite
44	2 miles northwest of Anamosa	do	Iowa State penitentiary	do	do
45	Stone City	do	John A. Green	do	do
46	do	Jones	James & Ronan	Limestone	Dolomite
47	do	do	Henry Dearborn	do	do
48	1 mile south of Capitol City	Linn	S. F. Cummings	do	
49	1 mile southeast of Mount Vernon	do	D. S. Hunt	do	Dolomite
50	2 miles northeast of Cedar Rapids	do	Three Bohemians	do	
51	1 mile southeast of Cedar Rapids	Linn	E. J. C. Becker	Limestone	
52	1 mile south of Vinton	Benton	R. H. Quinn	do	Bituminous limestone
53	2 miles northwest of Vinton	do	Samuel Agnew	do	do
54	1 mile east of Garrison	do	Iowa Stone & Lime	do	Bituminous limestone and dolomite
55	4 miles northwest of Garrison	Benton	Stout & Co	do	
56	1 mile northeast of Le Grand	Tama	Le Grand Quarry Company	Limestone	Magnesian limestone
57	Quarry	Marshall	do	do	Calcareous dolomite and limestone
58	1½ miles north of Dallas	do	do	do	Limestone
59	2 and 4 miles south of Ames	Story	P. E. Chase, R. Conrad, R. Hannum	do	Dolomite
60	3 miles northeast of Earlham	Dallas	Lund & Boyer	do	Limestone
61	Iowa City	Johnson	Edward Crowley	Limestone	Siliceous limestone
62	do	do	L. O. Hoffman	do	Dolomite and limestone
63	10 miles north northwest of Iowa City	do	Penn Quarry Company and D. A. Schaeffer	do	Limestone
64	1½ miles south of Mount Vernon	do	John P. McCune	do	Bituminous dolomite
65	2½ miles southwest of Lisbon	Cedar	M. Carey and Charles Miller	do	Limestone
66	1 mile south west of Tipton	Cedar	Shearer & Gray	Limestone	Limestone and dolomite
67	Rochester	do	Rochester Quarry	do	Limestone
68	Cedar Bluff	do	Cedar Bluff Quarry	do	do
69	3 miles northwest of Walton	do	Kott & Hamm	do	do
70	4 miles northeast of Dixon	Clinton	J. D. Binford	do	Ferruginous dolomite and bituminous coal mate
71	2 miles southeast of Grand Mound	Clinton	J. Collenbranch	Limestone	Ferruginous dolomite
72	Leona	do	Klaus Nagel	do	do
73	do	do	William Bell	do	do
74	Clinton	do	John Anthony	do	do
75	do	do	Thomas Purcell	do	do
76	8 miles east of Long Grove	Scott	Hans Topp	Limestone	Ferruginous dolomite
77	1 mile north of Le Claire	do	Edward Thelenan	do	do
78	Davenport	do	A. C. Fulton	do	Limestone
79	do	do	William L. Cook	do	do
80	1 mile west of Davenport	Scott	E. S. Glaspell	do	do
81	do	do	Heinrich Schmeidt	Limestone	Limestone
82	Buffalo	do	Christian Metzger	do	Calcareous dolomite
83	3 miles northeast of Muscatine	Muscatine	A. M. Hare	do	do
84	5½ miles northwest of Washington	Washington	James Eckles and James Saville	do	Limestone
85	do	do	Minnick & Donovan	do	do

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

IOWA—MARBLE AND LIMESTONE—Continued.

Color	STRUCTURE.			GEOLOGICAL AGE OF FORMATION.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Drab	Variable	Massive	Even, medium to thick	Sub-Carboniferous	Kinderhook	1855	21
Light drab	Granular (oolitic)	Regular	do	do	do	1854	22
Fine, buff and olive	Fine, semi-crystalline	Irregular	do	Devonian	Hamilton	1877	23
Drab	do	Massive	Even, thin	do	do	1865	24
do	Medium, fine and compact	Irregular	Even, medium thick	do	do	1856	25
Mottled and light buff	Porphyritic, fossiliferous	Irregular	Uneven, thin	Devonian	Hamilton	1870	26
Pale green and drab mottled.	Semi-crystalline, porous	do	Uneven, variable thickness	Upper Silurian	Niagara	1866	27
Light drab and buff mottled.	Porous	Even and wavy	Even, medium thick	do	do	1869	28
Light drab	Vesicular	Uneven	do	do	do	1878	29
Buff and drab	Semi-crystalline, vesicular	Massive	do	Lower Silurian	Trenton	1871	30
Buff	Semi-crystalline, vesicular	Massive	Even, medium thick	Lower Silurian	Trenton	1860	31
Buff and drab	do	do	do	do	do	1850	32
Mottled drab	Semi-crystalline, vesicular, and porous	Irregular	Even and thick	do	do	1869	33
Buff	do	do	Even, medium to thick	do	do	1876	34
do	Finely semi-crystalline	do	Even, medium thick	Upper Silurian	Niagara	1847	35
Buff	Semi-crystalline and porous.	Massive	Even, medium thick	Upper Silurian	Niagara	1870	36
do	do	do	Even, thick	do	do	1869	37
Light buff	Finely crystalline, vesicular.	Even and parallel	Even, thin to medium	do	do	1851	38
do	Porous and vesicular	Wavy	do	do	do	1855	39
do	do	do	do	do	do	1868	40
Light buff	Porous and vesicular	Wavy	Even, thin to medium	Upper Silurian	Niagara	1870	41
do	do	do	do	do	do	1872	42
do	Porous	Even and parallel	do	do	do	1865	43
Buff	Semi-crystalline and vesicular.	Fine, even, and parallel	Even, medium to thick	do	do	1879	44
Light drab	Fine, vesicular	Massive	Even, medium thick	do	do	1869	45
Light buff	Fine, homogeneous	Massive	Even, medium thick	Upper Silurian	Niagara	1869	46
Light buff and light drab	Semi-crystalline, vesicular	do	Even, thick	do	do	1869	47
Drab with pink spots	do	Irregular	Even, medium thick	do	do	1880	48
Buff	Fine, porous	Even and massive	Even, thick	do	do	1873	49
Drab	Variable	Irregular	Uneven, medium thick	Devonian	Hamilton	1860	50
Drab	Variable	Irregular	Uneven, thick to medium	Devonian	Hamilton	1872	51
Light gray or buff	Semi-crystalline, porous, and compact.	Irregular and massive	Even, medium thick	do	do	1861	52
do	do	do	Even, medium to thick	do	do	1858	53
Drab and mottled drab	Fine, compact, porphyritic.	Irregular	Even, medium thick	do	do	1868	54
do	Medium and fine	do	do	do	do	1872	55
Bluish gray	Semi-crystalline, partly oolitic.	Irregular	Even and thick	Sub-Carboniferous	Kinderhook	1866	56
Light drab and buff reddish brown.	Granular	Irregular and massive	Even, medium to heavy	do	do	1866	57
do	do	Massive	Even and thick	do	Keokuk	1876	58
Drab and buff	Fine, compact	do	Uneven, medium thick	do	Saint Louis	1862	59
Light drab	Semi-crystalline, fossiliferous.	do	Even, medium thick	Carboniferous	Upper Coal Measures.	1872	60
Plain and mottled drab	Semi-crystalline	Irregular	Heavy bedded	Devonian	Hamilton	1869	61
Light and dark drab	Compact and semi-crystalline.	Massive	do	do	do	1868	62
Pinkish gray	Semi-crystalline, porous	Irregular	do	do	do	1844	63
Light buff	Fine, finely porous	Even and massive	Even and thick	Upper Silurian	Niagara	1848	64
do	Vesicular	Even and parallel	Even, medium thickness	do	do	1865	65
Light buff	Vesicular	Even and parallel	Even, medium thick	Upper Silurian	Niagara	1868	66
do	do	do	Even, medium thickness	do	do	1875	67
do	do	do	do	do	do	1855	68
do	do	do	do	do	do	1853	69
Light buff and dark buff	Semi-crystalline and porous	Even and massive	Even, thin to medium	do	do	1840	70
Light buff and dark buff	Semi-crystalline and porous	Even and massive	Even, medium thickness	Upper Silurian	Niagara	1865	71
Deep buff	Finely semi-crystalline and vesicular.	Irregular	Even, medium to thick	do	do	1865	72
do	do	do	Even, medium thickness	do	do	1870	73
do	do	do	Even, medium to thick	do	do	1864	74
do	do	do	do	do	do	1858	75
Light buff	Finely semi-crystalline	Massive	Even, medium thickness	Upper Silurian	Niagara	1861	76
do	do	do	Even, variable thickness	do	do	1877	77
Drab	Vesicular, conchoidal fracture.	Wavy	Uneven, thick to medium	Devonian	Hamilton	1875	78
Mottled drab	Semi-crystalline, fossiliferous.	Irregular and massive	Uneven, thin to medium	do	do	1848	79
do	do	Massive	Uneven, medium thickness	do	do	1866	80
Light mottled drab	Semi crystalline, fossiliferous.	Massive	Uneven, thin to medium	Devonian	Hamilton	1871	81
Bluish-gray mottled	Porphyritic and fossiliferous	Irregular	Uneven, medium thickness	do	do	1857	82
Drab	Semi crystalline	do	Uneven, medium thick	do	do	1869	83
Light gray and buff	Granular and highly crystalline.	Massive	Even, thin to medium	Sub-Carboniferous	Saint Louis	1858	84
do	do	do	Irregular, thin to medium	do	do	1855	85

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

IOWA—MARBLE AND LIMESTONE—Continued.

	Location of quarry.	County.	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
86	Near Brighton	Washington	Brighton Quarries	Limestone	Limestone
87	Sigourney	Keokuk	Rowland Pilkington	do	do
88	3 miles north of Sigourney	do	William S Booton	do	do
89	1 mile south of Given	Mahaska	Francis Castles	do	Ferruginous and siliceous limestone
90	4 miles north northeast of Pella	Marion	T C Mathes	do	Limestone
91	2½ miles northwest of Durham	Marion	C. C. Collins	Limestone	Bituminous limestone
92	1½ miles southwest of Tracy	do	Regan Brothers & McGorrisk	do	Limestone
93	3 miles northwest of Knoxville	do	J. Johnsen	do	Siliceous limestone
94	1 mile south and southeast of Winterset.	Madison	G. W. Retcher	do	Limestone
95	do	do	T. F. Mardis	do	do
96	Winterset	Madison	City of Winterset	Limestone	Limestone
97	6 miles southwest of Winterset	do	W. H. Lewis	do	do
98	2 miles east of Earlham	do	Regan Brothers & McGorrisk	do	do
99	2½ miles east of Earlham	do	Robertson & Willoughby	do	do
100	Carson	Pottawattamie	Charles Tornenohm	do	do
101	Macedonia	Pottawattamie	Miles Quarry	Limestone	Limestone
102	1 mile southwest of Macedonia	do	Sylvester Dye	do	do
103	Crescent City	do	Crescent City Quarry	do	
104	Stennett	Montgomery	Wayne Stennett	do	Limestone
105	Near Corning	Adams	Law & Oak (2 quarries)	do	Siliceous limestone
106	5 miles northwest of Osceola	Clarke	F. J. Dean	Limestone	
107	¼ mile south of Chillicothe	Wapello	Samuel Strawn	do	Limestone
108	4 miles northwest of Ottumwa	do	S. L. Wiley Construction Company	do	do
109	3 miles northwest of Ottumwa	do	Chilton & Kendall	do	do
110	3 miles west of Ottumwa	do	James Kelly	do	do
111	2½ miles west of Ottumwa	Wapello	B. W. Jeffries	Limestone	Limestone
112	Ottumwa	do	Thomas Rogers	do	do
113	do	do	John Pasten	do	do
114	Dudley	do	Beckwith & Winters	do	do
115	5 miles west of Fairfield	Jefferson	Saul Stieber	do	Micaceous limestone
116	5 miles west of Fairfield	Jefferson	J. Ziegler	Limestone	Micaceous limestone
117	1½ miles south of Mount Pleasant.	Henry	Beckwith & Winters	do	Limestone
118	do	do	John Rikgaber	do	do
119	2 miles south of Mount Pleasant	do	Patrick O'Connor	do	do
120	Burlington	Des Moines	—— Hüsling	do	do
121	Burlington	Des Moines	Hoppman Bros. (2 quarries)	Limestone	Limestone
122	Keokuk	Lee	Miscellaneous	do	Dolomite
123	do	do	Patrick Tighe	do	do
124	do	do	James McNamara	do	
125	4 miles northeast of Franklin	do	Charles Graner	do	Ferruginous dolomite; also limestone.
126	Bentonsport	Van Buren	G. W. Jack	Limestone	Limestone
127	6 miles west of Keosauqua	Van Buren	Jacob Creasy	do	do
128	Bedford	Taylor	H. W. Greenlee	do	do

IOWA—SANDSTONE.

1	4 miles northeast of Muscatine	Muscatine	John Starke	Sandstone	Sandstone
2	3 miles northeast of Muscatine	do	A. M. Hare	do	do
3	½ mile southwest of Lewis	Cass	Jehu Woodward	do	Ferruginous sandstone

MISSOURI—CRYSTALLINE SILICEOUS ROCKS.

1	Knob Lick	Saint François	Allen & Smith	Granite	Hornblende granite
2	4 miles west of Iron Mountain	Iron	Philip Schneider & Co	do	Granite

MISSOURI—MARBLE AND LIMESTONE.

1	City of Saint Louis	Saint Louis	Moran's Quarry	Limestone	Dolomite
2	do	do	Daniel Cavenagh	do	do
3	do	do	Tim Evans	do	do
4	do	do	Joseph Webber	do	Limestone
5	do	do	Michael Kinealy	do	Dolomite limestone
6	City of Saint Louis	Saint Louis	James McGrath	Limestone	Dolomite limestone
7	do	do	A. O. Engelmann & Co	do	Dolomite
8	do	do	Diederich Scharringhaus	do	Magnesian limestone and limestone
9	do	do	Jos. O Meara & Brother	do	
10	do	do	William Gorman	do	

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

IOWA—MARBLE AND LIMESTONE—Continued.

Color.	STRUCTURE.			GEOLOGICAL AGE OF FORMATION.		Year in which operated.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Drab	Not homogeneous	Massive	Variable	Carboniferous	Lower Coal Measures.	1879	86
Light drab	Fine, compact, and porous	Massive and irregular	Even and thin	Sub-Carboniferous	Saint Louis	1861	87
do	do	do	Even, thin to medium	do	do	1874	88
Buff	Porous	Massive	Even, medium thickness	do	do	1879	89
Light drab	Granular and porous	do	Even, thick to medium	do	do	1856	90
Light drab	Granular and porous	Massive	Even, medium thick	Sub-Carboniferous	Saint Louis	1880	91
Light and dark drab	Compact and porous	do	do	do	do	1880	92
Dark gray	Coarse, semi-crystalline	do	Uneven, thick to medium	do	do	1862	93
Light drab	Granular, fossiliferous	do	Uneven, medium thick	Carboniferous	Upper Coal Measures.	1869	94
do	do	do	do	do	do	1878	95
Light drab	Granular, fossiliferous	Massive	Even, thick to medium	Carboniferous	Upper Coal Measures.	1860	96
do	do	do	Even and thick	do	do	1876	97
Light and dark drab	Semi-crystalline	Irregular	Even, medium thick	do	do	1869	98
do	do	Massive	do	do	do	1875	99
Light drab	Semi-crystalline and porphyritic.	Irregular	do	do	do	1880	100
Light drab	Semi-crystalline and porphyritic.	Irregular	Even, medium thick	Carboniferous	Upper Coal Measures.	1878	101
do	do	do	Uneven, medium thick	do	do	1856	102
do	do	do	Even, medium thick	do	do	1879	103
do	Granular	Massive	Even and thick	do	do	1880	104
Light drab and buff	Semi-crystalline, fossiliferous.	do	Even and thin	do	do	1860	105
Gray	Fine, homogeneous	Massive	Even, thin	Carboniferous	Upper Coal Measures.	1874	106
Mottled drab	Semi-crystalline	Irregular	Even and thin	Sub-Carboniferous	Keokuk	1879	107
Drab	Granular	Massive	Even, thin to medium	do	do	1877	108
Mottled drab	Semi-crystalline	Irregular	Even and thin	do	do	1879	109
Drab	Granular	Massive	Even, medium thick	do	do	1863	110
Mottled drab	Semi-crystalline	Irregular	Even, thin to medium	Sub-Carboniferous	Keokuk	1871	111
do	do	do	Even and thin	do	do	1877	112
do	do	do	Even, medium thickness	do	do	1866	113
Light drab and mottled drab.	do	do	Uneven, medium thickness	do	do	1866	114
Bluish gray and reddish gray.	Coarse, compact	Massive	Medium thick	do	Saint Louis	1872	115
Bluish gray and reddish gray.	Coarse, compact	Massive	Medium thick	Sub-Carboniferous	Saint Louis	1878	116
Light drab and buff	Semi-crystalline, porous	do	Medium, even thickness	do	Keokuk	1855	117
do	do	do	Even, variable thickness	do	do	1866	118
do	Semi-crystalline	do	Medium thick	do	do	1877	119
Light drab and mottled gray.	Variable	do	Medium thickness	do	Burlington	1867	120
Light drab and mottled gray.	Granular	Massive	Heavily bedded	Sub-Carboniferous	Burlington	1867	121
Olive gray	Variable	do	Uneven, medium thick	do	Keokuk	1857	122
do	Porous and compact	Uneven	Even and thick	do	do	1866	123
Gray	Coarse, porous	Irregular	Uneven, medium thick	do	do	1857	124
Buff and light drab	Porous	Massive	Even, medium thick	do	do	1857	125
Light and dark gray	Semi-crystalline, fossiliferous.	Irregular	Even, medium to thick	Sub-Carboniferous	Keokuk	1856	126
Drab	Semi-crystalline, finely granular.	Even, oblique	Even and thick	do	Saint Louis	1850	127
Buff	Semi-crystalline	Massive	Even, thick	Carboniferous	Upper Coal Measures.	1857	128

IOWA—SANDSTONE.

Dark brown	Coarse, friable	Coarse, oblique	Thick	Carboniferous	Coal Measures	1860	1
do	do	do	do	do	do	1876	2
do	do	Massive	Medium, thick	Cretaceous		1871	3

MISSOURI—CRYSTALLINE SILICEOUS ROCKS.

Gray and red	Medium	Massive	Parallel and vertical	Archæan		1872	1
Red	Coarse	do	do	do		1873	2

MISSOURI—MARBLE AND LIMESTONE.

Drab	Fine, fossiliferous	Massive	Even, medium to thick	Sub-Carboniferous	Saint Louis	1875	1
do	Fine, compact	Even and wavy	do	do	do	1866	2
do	Medium, fossiliferous	Massive	do	do	do	1879	3
do	Fine, compact	do	do	do	do	1875	4
do	Fine, fossiliferous	do	Medium thick	do	do	1875	5
Drab	Medium, semi-crystalline	Massive	Even, medium to thick	Sub-Carboniferous	Saint Louis	1845	6
do	Fine, fossiliferous	Irregular	do	do	do	1871	7
do	do	do	do	do	do	1875	8
do	do	do	do	do	do	1875	9
do	do	Massive	do	do	do	1872	10

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

MISSOURI—MARBLE AND LIMESTONE—Continued.

	Location of quarry	County	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
11	City of Saint Louis	Saint Louis	Engel Cabin	Limestone	Limestone
12	do	do	Brewster & De Hogan	do	do
13	do	do	Lemmon & Morrison	do	do
14	do	do	Schwartz & Voelbs	do	do
15	do	do	Phillip L. Stiel	do	Dolomite
16	City of Saint Louis	Saint Louis	Henry Perkinson	Limestone	Limestone
17	do	do	John McKenna	do	do
18	do	do	Joseph Lasseigne & Son	do	do
19	do	do	J. O. Meara	do	do
20	do	do	Gottfried L. Ehlmann	do	Dolomite
21	Rosedale	Saint Louis	Natural Stone Company	Limestone	Limestone
22	Jefferson City	Cole	H. W. Kirkbride	do	Siliceous dolomite and dolomite
23	Boonville	Cooper	Russell Quarry	do	Limestone
24	Sedalia	Pettis	Richard Anderson, lessee of Smith's quarry	do	Magnesian limestone, also dolomite
25	Flatrock south of Clinton	Henry	C. B. Jordan	Flag-stone	Argillaceous limestone
26	East of Kansas City	Jackson	John Bauman	Limestone	Magnesian limestone
27	Flats of Kansas City	do	James Dowling	do	Limestone

MISSOURI—SANDSTONE.

1	Miami Station	Carroll	White Rock Quarry Company	Sandstone	Sandstone (calcareous)
2	Warrensburg	Johnson	Bance & Veatch	do	do
3	do	do	Beedle Brothers	do	do
4	Clinton	Henry	Goodhardt Quarry	do	do
5	4 miles southwest of Sainte Genevieve.	Sainte Genevieve	Sainte Genevieve Sandstone and Granite Company.	do	do

KANSAS—SANDSTONE.

1	7 miles west of Fort Scott	Bourbon	Gilfillan Brothers	Sandstone	Sandstone (calcareous)
2	4 miles southwest of Pawnee	Crawford	Pawnee Flagstone Company	do	do

KANSAS—MARBLE AND LIMESTONE.

1	Englebow	Marshall	H. F. Gallagher	Limestone	Limestone
2	Frankfort	do	Joseph Wolson	do	do
3	Atchison	Atchison	Rockingham & Co	do	do
4	Manhattan	Riley	Veach Brothers	do	do
5	Topeka	Shawnee	McIvaine & Higginbotham	do	Dolomite and limestone
6	2 miles from Dunlap	Morris	Wolf, Pickens & Co	Limestone	Magnesian limestone
7	Lane	Franklin	Hanaway Brothers	do	Limestone
8	3 miles east of Cottonwood	Chase	L. W. Lewis	do	do
9	2 miles east of Cottonwood	do	Treadaday & Parker	do	Magnesian limestone
10	Cottonwood	do	Emsliee & Rettiger	do	do
11	1 mile west of Cottonwood	Chase	Lantry & Burr	Limestone	Limestone
12	Marion Center	Marion	Great Brothers	do	Dolomite
13	Florence	do	A. C. Horner	do	Magnesian limestone
14	Augusta	Butler	J. C. Hanes	do	Magnesian and siliceous limestone
15	Fort Scott	Bourbon	W. L. Wilkinson	do	Magnesian limestone and limestone
16	2 miles east of Winfield	Cowley	Charles Schmidt	Limestone	Siliceous and bituminous limestone
17	2 miles southeast of Winfield	do	Hodges, Moore & Co	do	Limestone

CALIFORNIA—CRYSTALLINE SILICEOUS ROCKS.

1	Penryn	Placer	Griffith Griffiths	Granite	Hornblende-biotite granite
2	Petaluma	Sonoma	John Golden & Bros. and others	Basalt	Basalt

WASHINGTON TERRITORY—CRYSTALLINE SILICEOUS ROCKS.

1	Wilkeson	Pierce	Northern Pacific Railroad Company	Granite	

WASHINGTON TERRITORY—SANDSTONE.

1	Bellingham Bay	Whatcom	C. Seidel & Co	Sandstone	

NEBRASKA—MARBLE AND LIMESTONE.

1	Roca	Lancaster	Keys & Bullock	Limestone	Limestone

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

MISSOURI—MARBLE AND LIMESTONE—Continued.

Color	STRUCTURE: Texture	STRUCTURE: Stratification	STRUCTURE: Jointing, bedding, or natural surfaces	GEOLOGICAL AGE OF FORMATION: Period.	GEOLOGICAL AGE OF FORMATION: Epoch.	Year in which opened.	
Drab	Fine, semi-crystalline	Massive	Even, medium to thick	Sub-Carboniferous	Saint Louis	1864	11
...do	Fine, fossiliferous	do	do	do	do	1869	12
...do	Fine, compact	do	do	do	do	1872	13
...do	Fine, semi-crystalline	do	do	do	do	1850	14
...do	Fine, fossiliferous	Irregular	Even, thick	do	do	1873	15
Drab	Fine, semi-crystalline	Massive	Even, medium to thick	Sub-Carboniferous	Saint Louis	1869	16
...do	Fine, fossiliferous	do	Medium, thick	do	do	1869	17
...do	do	do	Even, medium thick	do	do	1875	18
...do	Fine, semi-crystalline	do	do	do	do	1845	19
...do	Fine, compact	Irregular	do	do	do	1870	20
Drab	Fine, fossiliferous	Irregular	Medium, thick	Sub-Carboniferous	Saint Louis	1878	21
Light drab	Fine, vesicular	Massive	Even, thin to medium thick	Lower Silurian	Potsdam	1876	22
Dark drab	Medium, fossiliferous	do	Even, medium thick	Sub-Carboniferous	Saint Louis	1856	23
Brown and drab	do	do	Even, thick	Carboniferous	Burlington	1866	24
Dark drab	Fine, compact	Even and wavy	Even, thin to medium	Carboniferous	Lower Coal Measures.	1878	25
Gray	Granular, fossiliferous	Massive	Uneven, medium to thick	Carboniferous	Upper Coal Measures.	1869	26
Drab	Fine, fossiliferous	do	Thin to medium	do	do	1865	27

MISSOURI—SANDSTONE.

Light gray	Medium	Massive	Thick	Carboniferous	Lower Coal Measures.	1839	1
Gray	do	do	Even thick	do	do	1871	2
...do	do	do	do	do	do	1871	3
Light brown	do	do	Uneven, thick	do	do	1877	4
Light buff	Fine	do	Even, thick	Sub-Carboniferous	Chester	1869	5

KANSAS—SANDSTONE.

Light gray	Fine	Massive	Even, thin to medium	Carboniferous		1866	1
Greenish	Medium	do	Even, medium	do		1880	2

KANSAS—MARBLE AND LIMESTONE.

Light drab	Variable	Irregular	Even, medium	Permian		1870	1
..do	Coarse, vesicular	Massive	do	do		1874	2
Drab	Fine	Irregular	do	Carboniferous		1870	3
Buff	Coarse, vesicular	Massive	Even, thick	Permian		1865	4
Drab	Fine, fossiliferous	do	Uneven, thick	Carboniferous		1870	5
Light drab	Medium, vesicular	Irregular	Even, thin to thick	Permian		1878	6
Gray and buff	Medium, oolitic, & vesicular	do	Uneven, thin to thick	Carboniferous		1878	7
Light drab	Medium, fossiliferous	Massive	Uneven, thick	Permian		1880	8
..do	Fine, fossiliferous	do	Even, medium to thick	do		1879	9
...do	Medium, fossiliferous	do	Even, thick	do		1873	10
Light drab	Coarse, vesicular	Massive	Even, thick	Permian		1878	11
..do	Medium, vesicular	do	Even, thin to thick	do		1880	12
...do	do	Irregular, wavy	do	Carboniferous		1875	13
...do	do	Massive	Even, medium to thick	do		1880	14
Dark drab	Fine, semi-crystalline	Irregular, wavy	Even, thin to medium	Carboniferous		1879	15
Light drab	Fine, vesicular	Even, parallel	Even, thin to medium	Permian		1880	16
..do	do	Irregular, wavy	Even thick	do		1877	17

CALIFORNIA—CRYSTALLINE SILICEOUS ROCKS.

Black, dark gray, and white	Medium	Massive	Vertical	Archæan		1864	1
Dark gray	Fine	do	Irregular	do		1864	2

WASHINGTON TERRITORY—CRYSTALLINE SILICEOUS ROCKS.

Dark gray	Fine	Massive	Irregular	Archæan		1879	1

WASHINGTON TERRITORY—SANDSTONE.

Greenish gray	Medium	Massive	Uneven, thick	Carboniferous		1872	1

NEBRASKA—MARBLE AND LIMESTONE.

Drab	Medium	Massive	Even, thick	Permian		1870	1

TABLE IV.—TABLES INDICATING THE AMOUNT AND KINDS

DAKOTA—SANDSTONE.

	Location of quarry.	County	Name of the corporation, company, or individual.	Specific variety of stone.	
				Popular name.	Scientific name.
1	Sioux Falls	Minnehaha	George Boardman	Quartzite	Quartzite

COLORADO—VOLCANIC ROCKS.

1	Castle Rock	Douglas	B. Hammer	Eruptive rock	Rhyolite
2	2½ miles from Castle Rock	do	G. F. Girardot	do	do
3	Douglas	do	S. W. Madge	do	do

COLORADO—SANDSTONE.

1	7 miles southwest by west of Fort Collins.	Larimer	E. B. Yont	Sandstone	
2	Morrison	Jefferson	Garfield & Co	do	
3	2½ miles south of Morrison	do	A. H. Garfield & Co	do	

OF ROCKS QUARRIED IN THE DIFFERENT STATES.

DAKOTA—Sandstone.

Color.	Structure.			Geological age of formation.		Year in which opened.	
	Texture.	Stratification.	Jointing, bedding, or natural surface.	Period.	Epoch.		
Reddish purple	Fine, compact	Massive	Even, medium	Lower Silurian		1872	1

COLORADO—Volcanic Rocks.

Gray	Vesicular	Massive	Irregular			1878	1
Drab	do	do	do			1877	2
Gray	Fine	do	do			1875	3

COLORADO—Sandstone.

Gray	Medium	Even, parallel	Even, thin to medium	Cretaceous		1871	1
White	Fine	Massive	Even, thick	Jurassic			2
Red	do	Irregular	Uneven, thin	do			3

TABLE V.—SHOWING THE EXTENT OF STONE CONSTRUCTION IN

	City.	State	NUMBER OF STONE BUILDINGS. Total	Entirely of stone	With stone trimmings only	Per cent age of all brick and stone.	NUMBER OF BUILDINGS OF THE DIFFERENT CLASSES OF STONE, WITH LOCATION OF QUARRIES. Sandstone chiefly. No	Location of quarry.	Marble or limestone chiefly. No	Location of quarry.	Granite or crystalline siliceous rocks. No.	Location of quarry.
1	Akron	Ohio	24	11	13	0.75	24	Akron and Berea				
2	Albany	N. Y.	125	13	112	0.76	115	Connecticut brownstone	1	Trenton	4	Maine
3	Allegheny	Pa	45	15	30	3.44	10	Freeport, Pa., Massillon, Ohio.				
4	Allentown	Pa	15	12	3	0.7	1	Pennsylvania	14	Vicinity		
5	Altoona	Pa	10	3	7	0.30	10	Vicinity and Amherst, Ohio.				
6	Amsterdam	N. Y	22	20	2	1.83	17	Amsterdam	5		8	Stone mountain and vicinity.
7	Atlanta	Ga	8	3	5	0.11						
8	Auburn	N. Y	77	45	32	1.75	1	Connecticut	76	Vicinity		
9	Baltimore	Md	220	28	24	0.28	85	Connecticut, New Jersey, and Ohio	178	Maryland and Virginia	31	Maryland, Virginia, and Maine.
10	Bangor	Me	10	3	7	0.42					10	Frankfort and Penobscot islands.
11	Binghamton	N. Y	5	5		0.15			5	Syracuse		
12	Boston	Mass	771	93	678	1.70	346	Connecticut valley, New Jersey, Ohio, and provinces.	68	Vermont	312	Concord, cape Ann, and Chelmsford.
13	Bridgeport	Conn	39	16	23	0.87	27	Portland			12	Greenwich
14	Buffalo	N. Y	86	51	35	0.33						
15	Burlington	Iowa	100	95	5	2.00	1	Amherst, Ohio	99	Burlington		
16	Cambridge	Mass	14	13	1	0.17	1	Nova Scotia	1	Roxbury	11	Quincy and Rockport.
17	Camden	N. J	35	20	15	0.43	10	Trenton and Connecticut	16	Vermont		
18	Canton	Ohio	55	4	51	1.43	45	Massillon				
19	Cedar Rapids	Iowa	7		7	0.28			7	Stone City		
20	Charleston	S. C	8	1	7	0.11	8	Connecticut				
21	Chattanooga	Tenn	4	1	3	0.14			3	Vicinity	1	Georgia
22	Chelsea	Mass	4	2	2	0.12	2	Vicinity			2	Cape Ann
23	Chester	Pa	30			1.00					30	Vicinity
24	Chicago	Ill	5,003	453	4,550	5.00	500	Ohio and Michigan	4,500	Cook county and Rutland, Vt.	2	Maine
25	Chillicothe	Ohio	8	7	1	0.42	8					
26	Cincinnati	Ohio	2,500	100	2,400	8.00	1,490	Portsmouth	1,000	Cincinnati, Dayton, and Indiana.	1	Maine and Missouri
27	Cleveland	Ohio	250	170	80	0.78	249	Amherst, Independence and Elyria	1	Sandusky		
28	Columbus	Ohio	40	10	30	0.43	34	Berea, Waverly, Black Lick and Sugar Grove	6	4 miles west of Columbus		
29	Concord	N. H	6	6		0.4					6	Concord
30	Cumberland	Md	8	6	2	0.75	8	Vicinity				
31	Davenport	Iowa	50	40	10	1.14	2		48	Davenport, Buffalo, Le Claire and Stone City		
32	Dayton	Ohio	125	55	70	1.65	50	Portsmouth and Berea	75	Dayton		
33	Denver	Colo	50	12	38	0.83					8	Castle Rock
34	Derby	Conn	12	12		0.65					12	Ansonia and Birmingham.
35	Des Moines	Iowa	12	2	10	0.17			12	Earlham, Pella and Tracy.	1	Sauk Rapids, Minn., Iron Mountain, Mo., Grundy and Buchanan counties.
36	Detroit	Mich	75	15	60	0.27	60	Amherstburg, Essex county, Ontario, and Berea, Ohio	15	Trenton and Kelley's island, Ohio		
37	Dubuque	Iowa	200	150	50	4.00			200	Dubuque and Farley, and Savanna, Ill		
38	Easton	Pa	35	20	15	1.40	17	New Jersey and Pennsylvania.	18	Vicinity		
39	Elizabeth	N. J	15	3	12	0.27	15	Newark and Belleville.				
40	Elmira	N. Y	15	3	12	0.37	2	Vicinity	1	Syracuse		
41	Erie	Pa	5	4	1	0.13	2	Medina and Amherst	3	Dorset, Vt		
42	Evansville	Ind	100	1	99	1.66			100	Elliettsville and Bedford		
43	Fall River	Mass	67	50	17	1.09					45	Fall River
44	Fitchburg	Mass	4	2	2	0.19					4	N. H. and Fitchburg
45	Fort Wayne	Ind	5	2	3	0.17	1	Amherst, Ohio	4	Joliet, Ill., Wabash		
46	Galveston	Tex	102		102	2.40					102	Conn
47	Gloucester	Mass	14	6	4	0.33					10	Gloucester
48	Grand Rapids	Mich	12	3	9	0.19	9	Berea, Vista and Amherst, Ohio, and Ionia county, Mich.	3	Vicinity		
49	Hamilton	Ohio	8	3	5	0.25	5	Near Portsmouth, Ohio.	3	Hamilton		
50	Harrisburg	Pa	17	13	4	0.28	6	York and Lancaster counties and Hummelstown	10	Texas, Maryland, and Cumberland county, Pa	1	Bluehell, Me., and near Richmond, Va.
51	Hartford	Conn	136	36	100	1.94	112	Portland	9	East Canaan	15	Westerly, R. I., and Glastonbury.
52	Haverhill	Mass	16	1	15	0.64						
53	Indianapolis	Ind	234	9	225	1.59	7	Portsmouth, Ohio	227	Indiana		
54	Ithaca	N. Y	15	15		0.60	15	Vicinity				
55	Janesville	Wis	10	5	5	0.36			10	Lucity		

SOME OF THE PRINCIPAL CITIES OF THE UNITED STATES.

Stone employed for foundations.	STONE PAVEMENTS.				Stone commonly used for curb.	
	Street.		Sidewalk.			
	Extent used.	Location of quarries.	Extent used.	Location of quarries.		
Sandstone	Little	Medina	Largely	Berea, Ohio	Sandstone	1
Limestone	Largely	New England	do	Hudson river	Bluestone	2
Sandstone	do	(Cobble-stone) Allegheny river.	Considerable	Allegheny and Fayette counties	Sandstone	3
Lime and mountain stone	Little	(Cobble-stone) river	Little	Lehigh and Wyoming valleys and North river.	Limestone	4
Sandstone and conglomerate.	Largely	(Cobble-stone) streams	do	Eastern Pennsylvania	Sandstone	5
Limestone			Largely	Vicinity	Limestone	6
Granite and gneiss	10 miles	Stone mountain and vicinity (macadamized).	One half	Stone mountain and vicinity	Granite	7
Limestone	Little	Medina	Largely	East bank Cayuga lake	Sandstone	8
Gneiss	About three-fourths	Baltimore county and Jones' falls and vicinity.	do	Rondout, N. Y	Gneiss	9
Slate and bowlders	Little	Mount Desert, islands of Penobscot.			Granite	10
Limestone			Largely	Pennsylvania		11
Granite, slate, and Roxbury stone.	67 miles	Quincy, Bergen Hill, N. J., Rockport, Me.	do	North river, Rockport, Bolton, Conn., and Quincy.	Granite and blue-stone	12
Gneiss	Little	New Haven	Considerable	North river	Blue-stone and gneiss	13
	Largely	Medina	Largely	Medina	Sandstone	14
Limestone	Little	Vicinity	Little	Sagetown, Ill., and Mount Pleasant.	Limestone, Sagetown, Ill., and Mt. Pleasant.	15
Slate, diabase, and granite.	100 miles	Quincy	do	Hudson river	Granite and blue flagstone.	16
Gneiss	Largely	Connecticut	do	Williamsport, Pa	Granite	17
Sandstone	Considerable	Vicinity	Considerable	Berea, Ohio	Sandstone	18
Limestone			Little	Stone City	Limestone, Stone City and Farley.	19
			Largely	New York	Blue-stone	20
Limestone	Largely macadamized.	Vicinity	Little	Vicinity	Limestone	21
Granite	Little	Cape Ann and Quincy			Granite	22
Gneiss	do	(Cobble-stone) Delaware river.	Little	North river	Gneiss	23
Limestone	2 miles paved, 25 miles macadamized.	Waterloo, Wis., Lockport, N. Y., and other parts of New York.	36 miles	Lemont, Cook county	Limestone, Lemont	24
Sandstone	Little	Vicinity			Sandstone	25
Limestone	Largely	(Cobble) vicinity	Largely	Vicinity of Portsmouth	Limestone	26
Sandstone	do	Medina	do	Euclid and Newburgh	Sandstone	27
Corniferous limestone	Considerable	Vicinity	do	Columbus, Berea, and Waverly.	Corniferous limestone	28
Granite	Little	Concord	Little		Granite	29
Sandstone	Largely	(Bowlders) Potomac river	do	Southampton, Pa	Sandstone	30
Limestone	Largely macadamized	Davenport	Little	Stone City and Joliet	Limestone and sandstone, Stone City and Joliet, Ill.	31
do	Largely	Dayton	Largely	Dayton	Limestone	32
Rhyolite and sandstone			Little	Fort Collins		33
Gneiss			do	North river	Blue-stone and gneiss	34
Limestone	Little macadamized	River gravel	do	Joliet, Ill	Limestone, Joliet, Ill., Earlham and Pella	35
Limestone	Little	Medina	Largely	Cleveland and Euclid, Ohio, and Medina, Mich.	Limestone, Medina	36
do	5 % paved, balance macadamized.	Dubuque	Little	Stone City and Farley, and Joliet, Ill.	Limestone, Dubuque, Stone City, and Farley	37
do	Little	(Cobble-stone) Delaware river.	do	Meshoppen	Limestone	38
Brownstone	Largely	Hudson river and New England.	Largely	North river	Blue-stone	39
Sandstone	Two blocks	Medina	Little	Trumansburg	do	40
Sandstone	Largely	Medina	Little	Euclid, Ohio	Sandstone	41
Limestone	Little	Vanderburgh county	Largely	Bedford and North Vernon	do	42
Granite	do	Fleetown	Little	North river, N. Y	Granite	43
do	do	Fitchburg			do	44
Limestone	do	Wabash	Little	Berea, Ohio, and Joliet, Ill	Limestone	45
Sandstone, limestone, and granite.	Little	Cobble, ship ballast	Little	Connecticut, England, and Germany.	Limestone, sandstone, and granite.	46
Syenite	do	Gloucester			Syenite	47
Bowlders and some limestone.	do		Little	Lemont and Joliet, Ill., and Cayuga county, N. Y.	Limestone, Joliet, Ill	48
Limestone	do	(Cobble) vicinity	do	Hamilton	Limestone	49
do	do	(Cobble) Susquehanna river.	do	Hoboken, N. J	Brownstone and granite	50
Sandstone	Largely	Southwest of Hartford	Largely	North river and Bolton	Gneiss and blue-stone	51
Granite	Little	Cape Ann			Granite	52
Limestone	do	(Bowlders) vicinity	Largely	Decatur county	Limestone	53
Sandstone			do	Vicinity	Blue-stone	54
Limestone	3 miles	In city	1½ miles	In city	Limestone	55

TABLE V.—SHOWING THE EXTENT OF STONE CONSTRUCTION IN

	City.	State.	NUMBER OF STONE BUILDINGS. Total.	Entirely of stone.	With stone fronts only.	Percentage of all buildings.	NUMBER OF BUILDINGS OF THE DIFFERENT CLASSES OF STONE, WITH LOCATION OF QUARRIES. Sandstone chiefly. No.	Location of quarry.	Marble or limestone chiefly. No.	Location of quarry.	Granite or crystalline siliceous rocks. No.	Location of quarry.
56	Johnstown	Pa	10	2	8	0.27	9	Connecticut valley and vicinity of Johnstown.				
57	Joliet	Ill	500	300	200	10.00			500	Vicinity		
58	Kansas City	Mo	95	15	80	1.00	70	Warrensburg, Carroll county, and Barnard, Kans.	25	Junction City, Kans		
59	Keokuk	Iowa	18	12	6	0.75	3	Sonora Ill	9	Vicinity		
60	Kingston	N. Y	54	50	4	1.47	1	Vicinity	35	...do		
61	La Crosse	Wis	20	12	8	0.57			20	East of city		
62	La Fayette	Ind	7		7	0.33			7	Bedford, Ind		
63	Lancaster	Pa	21	15	6	0.41	2	Lancaster county	16	Vicinity and Montgomery county.		
64	Lawrence	Mass	5	5		0.10					4	Concord, N. H
65	Leavenworth	Kans	3	3		0.09			3	Leavenworth		
66	Lockport	N. Y	286	185	101	7.50	150	Vicinity	35	Vicinity		
67	Logansport	Ind	60	0	0	3.75			60	Logansport		
68	Louisville	Ky	469	94	375	1.92	40	Portsmouth, Ohio	360	Bowling Green, Ky., and Bedford, Ind.		
69	Lowell	Mass	46	43	3	0.51	34	Lowell	1	Rutland, Vt	11	Concord, N. H., and Westford.
70	Lynn	Mass	28	5	23	0.41					5	Cape Ann and Peabody
71	Madison	Wis	76	48	28	4.00	73	3 miles west of city and Indiana.	3	Bridgeport and Westport, Ind.		
72	Manchester	N. H	3	1	1	0.10						
73	Mansfield	Ohio	3	1	2	0.15	3					
74	Memphis	Tenn	10	2	8	0.50	2	Ohio and Alabama	7	Alabama and Kentucky	1	
75	Middletown	Conn	21	14	7	1.05	20	Portland			1	Haddam
76	Minneapolis	Minn	242	224	18	3.18	1	Fond du Lac	241	Minneapolis and Lemont, Ill.		
77	Mobile	Ala	1	1		0.02					1	Massachusetts
78	Nashua	N. H	3	3		0.11					3	Nashua
79	Nashville	Tenn	97	7	90	1.24	4		93	Bowling Green, Ky		
80	New Albany	Ind	15	3	12	0.45	2	New Albany	13	Salem		
81	Newark	N. J	216	76	140	1.05	210	Newark and Ohio	6			
82	New Bedford	Mass	25	22	3	0.57					22	Rockport, Quincy, and vicinity.
83	New Brunswick	N. J	11	11		0.31	9	Newark and Connecticut			1	New York
84	Newburgh	N. Y	13	10	3	0.36	1	Kingston	12	Vicinity and Ulster county.		
85	Newburyport	Mass	2	2		0.10	1	Springfield			2	Cape Ann
86	New Haven	Conn	69	27	42	0.66	59	Portland, East Haven, and Ohio.	1		9	Long island, East and West Rocks.
87	New London	Conn	18	14	4	1.05	2	Portland	1		15	New London and Groton.
88	Newport	R. I	40	30	10	1.33	14				25	Newport
89	Newton	Mass	7	7		0.22	5	Ohio and Massachusetts			2	Westford
90	Norristown	Pa	35	30	5	1.34	28	Pottstown and vicinity of Norristown.	7	Montgomery county	7	
91	North Adams	Mass	6	6		0.30	2		3	Adams		
92	Northampton	Mass	4	2	2	0.21	2	Longmeadow, Mass., and Portland, Conn.				
93	Norwich	Conn	14	6	8	0.42	10	Portland and Ohio			4	Massachusetts and vicinity.
94	Ogdensburg	N. Y	260	250	10	13.00	2	Ohio	258	Vicinity		
95	Orange	N. J	25	25		0.50	22	Orange			3	Orange
96	Oshkosh	Wis	5		5	0.14	1	Marquette	4	Vicinity		
97	Oswego	N. Y	55	51	4	1.28	46	Oswego and vicinity	2	Onondaga county	2	Vicinity
98	Paterson	N. J	50	50		0.68	50	Little Falls and Paterson				
99	Pawtucket	R. I	6	5	1	0.33	1	Nova Scotia			5	Vicinity
100	Petersburg	Va	3	1	2	0.05	2	Connecticut			1	Dinwiddie county
101	Philadelphia	Pa	10,518	6,000	4,518	6.25	3,518	Connecticut, Trenton, N. J., Ohio, and Humelstown	2,500	Montgomery county, Massachusetts, and Vermont.	3,500	Quincy, cape Ann, Mass., Fox island, Me., New Hampshire, Rhode Island, Virginia, and Philadelphia, and Delaware county, Pa.
102	Pittsburgh	Pa	90	30	60	0.34	81	Pennsylvania, Massillon, Ohio, Baden, Homewood, and Freeport	2	Lemont, Ill		
103	Pittsfield	Mass				0.25			3	New York state and Sheffield.	2	Longmeadow and Quincy.
104	Portland	Me	30	10	20	1.00	10	Nova Scotia	1	Vermont	19	Hallowell, Biddeford, vicinity of Portsmouth.
105	Portsmouth	N. H	4	4		0.13					4	

SOME OF THE PRINCIPAL CITIES OF THE UNITED STATES—Continued.

Stone employed for foundations.	STONE PAVEMENTS.				Stone commonly used for curb.	
	Street.		Sidewalk.			
	Extent used.	Location of quarries.	Extent used.	Location of quarries.		
Sandstone	Largely	(Cobble-stone) streams			Sandstone	56
Limestone			Largely	Vicinity	Limestone in vicinity	57
do	Principal streets, also macadamized.	Medina, N. Y	Little	Winfield, Fort Scott, Florence, Kans., and Joliet, Ill.	Limestone, Kansas City	58
do			do	Vicinity	Limestone in vicinity	59
Flagging	Little		60 miles	Kingston, Ulster, and Hurley	Blue-stone	60
Limestone	2 miles	East of city	Little	East of city	Limestone	61
do	Little	(Bowlders) vicinity	do	Greensburg	do	62
do	Largely	Vicinity	Largely	Wyoming county	Dolerite	63
Granite	do	Cape Ann and Westford	Little	Cape Ann	Granite	64
Limestone	do	Vicinity	do	Fort Scott (near)		65
Limestone	Little	Medina	Little	Vicinity	Sandstone	66
do	do	(Bowlders) vicinity	Largely	Southern Indiana	Limestone	67
do	Largely	Louisville	Little	Bowling Green	do	68
Granite	do	Westford, Mass., and Concord, N. H.	do	Westford	Granite	69
do	Considerable	Cape Ann			do	70
Sandstone	Considerable	Vicinity	Little	Joliet, Ill., and Ohio	Sandstone	71
						72
Sandstone	Largely	Vicinity	Largely	Warren	Sandstone	73
	15 miles	Illinois, Kentucky, Alabama, and Tennessee.	Little	Alabama	Limestone	74
Sandstone			Largely	Haddam and Maromas	Gneiss	75
Limestone	Little	Cobble, from drift	Little	Joliet, Ill., and vicinity of Minneapolis.	Limestone, Minneapolis	76
	Business portion partly paved and macadamized.	Ballast, foreign vessels			Limestone	77
Granite	½ mile	Nashua	Little		Granite	78
Limestone	Largely macadamized	Vicinity	do	Vicinity	Limestone	79
Limestone	Largely	New Albany	Little	New Albany and North Vernon.	Limestone	80
Sandstone	do	Hudson river and New England.	Largely	Ulster county	Blue-stone	81
Granite	do	Vicinity	do	North river, N. Y	Granite	82
Sandstone	do	West Connecticut	do	do	Blue-stone	83
Limestone	2 miles	Cobble-stone, vicinity	do	Ulster county	do	84
Granite	Little	Maine			Granite	85
Trap and sandstone	Largely	East and West Rocks	Little	North river and Bolton	Blue-stone and granite	86
Bastard granite	Little	Groton	Principal streets	North river	Granite	87
Granite	do	Block island and Nova Scotia.	Little	Hudson river	do	88
Wallstone			do	Westford	do	89
Sandstone	Little	Quincy	Considerable	North river	Granite, gneiss	90
Limestone	Chiefly on Eagle street		One block		Blue-stone, limestone, and quartzite.	91
Sandstone	Little		Little	Smith's Ferry	Granite	92
Talcose	do		Largely	North river	Blue-stone	93
Limestone		Potsdam and Hammond	Little	Potsdam	Potsdam and limestone	94
Sandstone	Little	Vicinity	Largely	Ulster county	Blue-stone	95
Limestone			Less than ¼ mile	Fond du Lac, Joliet, Ill		96
Sandstone	Little	Vicinity	Little	Cayuga	Sandstone and limestone	97
do	Largely	do	25 miles	North river and Sullivan county.	Blue-stone	98
Blue and red slate	Little	Diamond Hill	Little	Hudson river	Granite and blue-stone	99
Granite	do	(Cobble) vicinity	do	Petersburg	Granite	100
Limestone and gneiss	Largely	(Cobble) Delaware river, (rubble) local, Richmond and eastern granite.	Main streets in old portion of city.	North river and Wyoming valley.	Granite	101
Sandstone	do	(Cobble) Allegheny river.	Considerable	Allegheny and Fayette counties.	Sandstone	102
			One-half of business streets.	Catskill	Blue flagging	103
Ledge stone	Largely	Yarmouth, Hallowell, Fox island, and east Maine.	Little	Hudson river	Granite	104
Granite	Little	Sea-shore			do	105

TABLE V.—SHOWING THE EXTENT OF STONE CONSTRUCTION IN

	City.	State.	NUMBER OF STONE BUILDINGS				NUMBER OF BUILDINGS OF THE DIFFERENT CLASSES OF STONE, WITH LOCATION OF QUARRIES.					
			Total.	Entirely of stone.	With stone fronts only.	Percentage of all buildings.	Sandstone chiefly.		Marble or limestone chiefly.		Granite or crystalline siliceous rocks.	
							No.	Location of quarry.	No.	Location of quarry.	No.	Location of quarry.
106	Portsmouth	Ohio	5		5	0.24	5	Vicinity				
107	Pottsville	Pa	50	49	1	1.89	47	Trenton, N. J., Connecticut and vicinity.				
108	Poughkeepsie	N. Y	24	5	19	0.96	16	Ohio and Portland	3	Westchester county	5	Vicinity
109	Providence	R. I	100	65	35	0.64	45	Connecticut, Nova Scotia, and New Jersey.	2	Tuckahoe, N. Y.	59	Smithfield, Quincy, Westerly, Cranston, and Providence.
110	Quincy	Ill	100	20	80	2.00	28	Cleveland and Berea, Ohio, Warrensburg, Mo.	72	Vicinity		
111	Quincy	Mass	7	7		0.40					7	Quincy
112	Racine	Wis	4	3	1	0.08	1	Lake Superior	3			
113	Reading	Pa	40	40		0.44	20	Vicinity				
114	Richmond	Ind	20		20	0.50	20	Berea, Ohio				
115	Richmond	Va	5	4	1	0.05					5	Vicinity and Massachusetts.
116	Rochester	N. Y	197	146	51	1.13	31	Ohio and Medina	100	Vicinity	2	
117	Rockford	Ill	100	100	10	1.66		do	100	do		
118	Rock Island	Ill	3	3		0.07			3	Rock Island		
119	Rome	N. Y	9	5	4	0.50	3	Verona, N. Y	3	Onondaga and Oneida counties.		
120	Saint Joseph	Mo	15		15	0.26	15	Warrensburg, Mo				
121	Saint Louis	Mo	1,525	105	1,420	3.32	905	Warrensburg and Sainte Genevieve, Mo., and Carroll county.	610	Saint Louis, Grafton, Joliet, and Chicago, Ill.	12	Missouri
122	Saint Paul	Minn	344	324	20	4.91	3	Kasota	336	Saint Paul and Frontenac.		
123	Salem	Mass	7	5	2	0.18	1	Springfield			4	Cape Ann and Peabody
124	Salt Lake	Utah	40	30	10	0.62	37	Red Buttes, Albany county, Wyoming Territory.			3	
125	Sandusky	Ohio	200	180	20	6.25	20	Amherst	180	City quarries		
126	San Francisco	Cal	29	4	25	0.08	4	New Castle island, B. C., and Angel island.			24	China and Placer county.
127	Saratoga Springs	N. Y	8	8		0.40			8	Vicinity		
128	Savannah	Ga	2	2		0.04					2	Massachusetts
129	Schenectady	N. Y	4	3	1	0.16	4	Vicinity				
130	Scranton	Pa	14	4	10	0.17	12	Catskill mountains and Luzerne county.	2	Syracuse, N. Y		
131	Springfield	Ill	16	5	11	0.27	5	Amherst, Ohio and vicinity of Springfield.	10	Joliet and Springfield	1	Virginia
132	Springfield	Mass	12	8	4	0.29	6	Longmeadow			6	Monson
133	Springfield	Ohio	25	5	20	0.63	1	New Portsmouth	24	Springfield and Dayton		
134	Steubenville	Ohio	12	2	10	0.50	12	Steubenville				
135	Taunton	Mass	10	8	2	0.33	7	Vicinity			3	Acushnet
136	Terre Haute	Ind	100		100	1.92			100	Ellettsville and Bedford		
137	Toledo	Ohio	12	4	8	0.12	10	Amherst and Berea	2	Sandusky		
138	Topeka	Kans	750	700	50	12.50	12	Warrensburg, Mo	738	Cottonwood, Junction City, Cowley county, and Topeka.		
139	Trenton	N. J	80	71	4	1.46	65	Connecticut and Ohio				
140	Troy	N. Y	728	8	720	9.21	716	Portland and Connecticut			7	Niskayuna
141	Utica	N. Y	27	10	17	0.39			6	Utica and Trenton		
142	Waterbury	Conn	5	4	1	0.17	1	Portland			4	Plymouth granite, county and vicinity.
143	Watertown	N. Y	24	22	2	0.96			24	City		
144	Wheeling	W. Va	16	4	12	0.31	16	Vicinity				
145	Wilkesbarre	Pa	16	6	10	0.34	12	Luzerne county and Meshoppen.	4	Syracuse, N. Y		
146	Williamsport	Pa	12	10	2	0.32	12	Hummelstown and vicinity.				
147	Wilmington	Del	22	10	12	0.26	9	Connecticut, Ohio, and New Jersey.	5	Cockeysville and Texas, Md.	6	Brandywine creek
148	Winona	Minn	10	10		0.50			10	Winona		
149	Woonsocket	R. I	20		2	1.33	2			Woonsocket		
150	Worcester	Mass	24	10	14	0.33	5	Longmeadow			19	Fitzwilliam, N. H
151	Yonkers	N. Y	6	2	4	0.19	4	Ohio and Portland			2	Vicinity
152	York	Pa	8	3	5	0.29	6	York county and Connecticut valley.	2	York	1	Richmond, Va
153	Zanesville	Ohio	12	4	8	0.36	9	Zanesville	3	Zanesville		

1. Serpentine has been used for building stone to a limited extent in a few of the above cities, but its importance is not sufficient to warrant giving it a place in the table. It may be mentioned that in the cities of Baltimore, Md., Wilmington, Del., Camden, N. J., Pottsville and Lancaster, Pa., there are a few buildings of this material, while in Philadelphia the number is estimated at 1,000.

2. For cities of New York and Washington, see detailed tables in the text.

SOME OF THE PRINCIPAL CITIES OF THE UNITED STATES—Continued.

Stone employed for foundations.	STONE PAVEMENTS.				Stone commonly used for curb.	
	Street.		Sidewalk.			
	Extent used.	Location of quarries.	Extent used.	Location of quarries.		
Sandstone	Little		Little	Vicinity	Freestone	106
Conglomerate			Considerable	do	Conglomerate	107
Limestone	Little		Largely	North river	Blue-stone	108
Cranstone stone and slate	16 miles	Diamond Hill, Westerly, Connecticut, and Maine.	Little	Hudson river and cape Ann	Granite	109
Limestone	Largely	Vicinity	do	Lemont and Joliet	Limestone	110
Syenite					Syenite	111
Limestone	Little	Racine	Little	Joliet, Ill		112
Limestone and sandstone			do	Hudson river	Limestone and blue flag	113
Limestone			do	New Paris, Ohio	Limestone	114
Granite	Business streets	(Cobble) near Richmond	do	Lynchburg, and Rondout, N. Y.	Granite	115
Limestone	Largely	Albion	Largely	Albion	Blue-stone	116
do	do	Vicinity	Little	Vicinity	Limestone, Joliet	117
do	Macadamized	Rock Island	do	Joliet	Limestone, Rock Island	118
Limestone and sandstone	Little		Largely	Cayuga, Chenango, and Hudson river.		119
Limestone	Macadamized	4 miles north of city	Little	Cottonwood Falls, Kans	Limestone, 4 miles north of city.	120
Limestone	Largely macadamized	Saint Louis and southeast Missouri.	Little	Saint Louis and Joliet, Ill	Limestone, Saint Louis	121
do	Little		Considerable	Saint Paul	Limestone, Saint Paul	122
Granite	Considerable	Cape Ann and Maine			Granite	123
Sandstone and granite						124
Limestone	Little		Largely	City quarries	Limestone	125
Granite rubble	4½ miles	Sonora and Penryn	Little	Folsom and Vermont	Granite	126
Limestone	Largely		Business streets	North river and Vermont	Blue-stone and marble	127
	Business streets	Cobble, ballast from vessels, and New York.	Little	Hudson	Flagstone	128
Sandstone	Largely	Glenville	Largely	Helderberg		129
Seral conglomerate	Little	(Cobble-stone) vicinity	Considerable	Lehigh and Susquehanna counties.	Sandstone	130
Limestone			Largely	Joliet	Limestone, Joliet and Alton.	131
Sandstone	Macadamized with trap	Westfield	Little	Hudson river and Monson	Sandstone and gneiss	132
Limestone	Little	Springfield	do	Springfield and Dayton	Lime stone	133
Sandstone	do	(Cobble-stone) Ohio river	do	Steubenville	Sandstone	134
Wallstone	do	Fields in vicinity	do	Acushnet	Granite	135
	Largely	Spencer	Largely	Bedford and Ellettsville	Limestone	136
Limestone	Little	Medina	Little	Berea and Euclid	Sandstone and limestone	137
do			do	Osage county and near Fort Scott.	Limestone Salford	138
Sandstone	Little	Lambertville	Considerable	North river	Blue-stone	139
Shale	Largely	Clark's island, Me	Largely	Hudson river	do	140
Sandstone	Largely	Medina and Hammond	Largely	Cayuga and Hudson river	Sandstone	141
Granitic rock			One-half of principal streets.	North river	Blue-stone, North river	142
Limestone			Little	Watertown	Limestone	143
Sandstone	Largely	(Cobble) Ohio river	do	Buena Vista	Sandstone	144
Red sandstone	Little	(Cobble) Susquehanna river.	Largely	Vicinity	Red sandstone	145
Sandstone	Little	Vicinity	Little	Meshoppen	Slaty and conglomerate	146
Granite	One-third of streets	do			Granite	147
Lime-rock			Little	Winona	Lime-rock, Winona	148
Granite and mica-schist	Little	Vicinity and Massachusetts.	do	Hudson river	Granite, gneiss	149
Gneissoid granite	Main business streets	Fitzwilliam, N. H	Business streets	Local and Fitzwilliam, N. H	Gneiss	150
Trap and gneiss	Little	Tomkins Cove	Largely	North river	Blue-stone	151
Limestone	Largely	Vicinity	Little	York county	Brown sandstone	152
Sandstone	do		Considerable	Berea	Blue limestone and sandstone.	153

Chapter VI.—DESCRIPTIONS OF QUARRIES AND QUARRY REGIONS.

GENERAL REPORT ON THE BUILDING STONES OF RHODE ISLAND, MASSACHUSETTS, AND MAINE.

By Professor N. S. Shaler.

In the following report I propose to give a short general account of the geological conditions in which the building stones of these states occur, with some remarks on the conditions that have retarded or favored the development of quarrying industry within their limits. This discussion will not include any matters of a purely scientific character, nor will it have to do with the statistical matters presented in the tables. The end in view will be the presentation of the most important facts connected with the quarrying industries that have not been made clear in the statistical reports.

GENERAL CONDITIONS OF THE BUILDING STONES OF NEW ENGLAND.

It is a fact well known to geologists that the New England peninsula, or the region east of the Hudson and of lake Champlain, has a more varied geological structure than is found in any other region of equal area within this continent. In the manifold nature of its geological elements it more nearly resembles the territory of old England than that of the rest of America. As the possible variety of the building stones in any county depends upon the number of kinds of rock that appear at the surface of the earth, this variety in the geological structure of New England has exercised a beneficial influence on the quarrying industry within its bounds. A much greater variety of rocks is quarried within its limits than in any other equal area of America. The greater part of these quarry products is derived from the very ancient rocks which owe their utility to the extensive metamorphism to which they have been subjected by the action of heat and pressure. Nearly all the rocks in this region have lost their original character, being much denser and more crystalline, and are frequently penetrated by joints and cleavage planes that at certain places and for certain purposes are a great advantage to the quarryman.

The following list of native quarried stones used in New England for building will give an idea of the variety of materials existing within this area. In the list the distinctly-bedded rocks which have been but little changed from their original condition are given first; below these the more highly metamorphosed materials. Considerable as this list is, it affords but an inadequate idea of the actual variety of these materials, inasmuch as it is not possible to set out in such a list the lesser differences that often serve greatly to alter the appearance and the use of particular stones. Moreover the purposes to which the stone is applied are often too numerous to be set forth in such a brief statement.

LIMESTONES.

White marble.—Ranging from qualities only a little less perfect than that of Carrara to blotched and variegated stone; used for building stone and the various minor constructural and ornamental purposes to which such stone is usually applied.

Red marble.—Mostly used for building purposes and for table-tops, floors, etc.

Black marble.—For inlay work, floors.

All the limestones that are quarried in New England are crystalline in their texture and are tolerably free from admixture of clay or magnesia; they are therefore all available for making lime and are largely used for this purpose. In their distribution they follow somewhat peculiar conditions. They are most abundant in western New England; *i. e.*, the western parts of Connecticut, Massachusetts, and Vermont, yet they appear again in considerable abundance on the eastern face of this region. In Rhode Island north and east of Providence occur large areas of limestone, probably belonging to the Lower Coal Measures or the sub-Carboniferous limestone, and in eastern Massachusetts, in the counties of Middlesex and Essex, some small areas of crystalline limestone of Archæan age occur, but not in sufficient quantities to afford a basis for industries. On the coast of Maine we have very important deposits of limestone that afford the basis for the largest industry in lime-making that has been developed within an equal area in the United States; but the physical conditions of the rock do not favor the quarrying of building or ornamental stones at this point.

None of these limestones are well suited for road-making materials, as their distinct crystalline structure causes them to shatter and fall into a powdery state beneath the wheels.

I estimate the area occupied by workable limestones in New England at not exceeding about 500 square miles; in Massachusetts, Rhode Island, and Maine the area is less than 200 square miles.

SANDSTONES AND CONGLOMERATES.

These rocks occupy an area considerably more extensive than that occupied by the limestones; it probably amounts to not less than 800 square miles of surface in all New England, and in Massachusetts, Rhode Island, and Maine includes about 600 square miles of area. The varieties and uses are approximately as follows:

FINE-GRAINED, REDDISH, AND BROWN SANDSTONES.—Used for flagging and the external walls of houses principally the latter.

CONGLOMERATES AND COARSE GRITS.—Used only for external walls.

Of these building stones the first group is very limited in extent, being confined to the immediate vicinity of the Connecticut river, between the northern part of Massachusetts and the mouth of the stream. The greater part of the material is composed of very uniform sand, in which oxide of iron is plentifully mingled. The material, quarries easily and works well under the chisel and the hammer; its endurance to weathering is, however, but slight in the variable climates of the northern United States, yet, on account of the ease with which these stones are worked and their very rich color, they have come into very extensive use in all the eastern cities north of Virginia. There are lighter colored and more flag-like stones of this same series that occur most abundantly in the region near Turner's Falls. These beds have been, at various times, worked for sidewalk flags, yet their use has not been large; it is from the rocks of this age and character that the foot-prints of various amphibians have been so plentifully obtained.

The conglomerates of New England have a very wide extension, but only in a few regions have they been worked to any extent. The only region where an extensive quarrying industry has been based upon them is in the neighborhood of Boston, Massachusetts. They are the building stones most accessible to that city, and so have come into very extensive use for wall work in buildings of a costly character. This stone is extremely durable and of a handsome reddish-yellow or gray color. Owing, however, to the infrequency of the joints in the rock the process of dressing is costly, the stone being perhaps the most expensive of any that has ever come into considerable use in this country. Its peculiar pebbly structure makes it singularly unsuitable for ornamental purposes, as it cannot be worked into any other than a flat surface. Except in Rhode Island, where the inferior carboniferous conglomerate is somewhat used for rough walling, the neighborhood of Boston is the only place where conglomerate has been extensively used for any building purposes; indeed we may say that conglomerates have been more generally used there than in any other city, European or American.

SLATES AND CLAY-STONES.

This group of rocks is very abundantly developed in New England, and has been made the basis of very extensive industries. The area occupied by workable rocks of this class is probably not less than 1,500 square miles in all New England, and perhaps exceeds 700 square miles in the states especially considered in this report. This group of very argillaceous rocks is to be divided into the two classes of slates proper and clay-stones on the basis of the relative fissility of the material given by the joints or cleavage planes. The slates proper are affected by true cleavage, and are almost indefinitely divisible by the cleaving-tools of the quarrymen. The clay stones have only a jointed structure and are not indefinitely divisible in this fashion. The following are in brief the uses of these two stones:

CLAY-SLATES.—Used for roofing slates, billiard and other table tops; chimney mantels (with or without artificial overfalls); flagging stones, school slates, bath-tubs, wash-tubs, etc.

CLAY-STONES OR ARGILLITES.—Used only for wall work. The geographical distribution of these slates and clay-stones is rather peculiar; they occur in one form or another over all parts of New England, yet the area of the deposits of workable quality is small and widely scattered. Of true slates Massachusetts has no workable deposits that have yet been discovered, and I think it very unlikely that any will be found; none are known in Rhode Island, though it is not impossible that both there and in Connecticut available deposits may yet be found. In Vermont and in Maine there are large areas of good roofing slates, and their development has been the basis of extended industries. The clay-slates have only been occasionally used, principally for road material and rough, dry walls. About Boston there are some quarries that have recently been used as sources of building material for churches and other large edifices. As yet, however, this class of stones has been much neglected. The first quarries in this country, certainly the first in Massachusetts, were opened in stones of this description. These are the quarries in Neponset, formerly Milton. The material was used for grave-stones, mile-stones, and, to a small extent, for flagging. (See second part of this report.)

HIGHLY METAMORPHOSED ROCKS.

Under this head I shall, for convenience, include all those rocks that have lost their original character by fusion or by a very complete metamorphism. The classification has no other merit than convenience. First in importance among these is:

GRANITIC ROCKS.—Used for a great variety of constructive and ornamental work.

SCHISTOSE ROCKS (GNEISS AND MICA SCHIST).—Little used for building save for rough walls. No important industries resting upon them.

TRAPPEAN ROCKS.—Very little used save for road material.

SERPENTINES AND STEATITES (VERD-ANTIQUES AND SOAPSTONES).—Extensively used, particularly the latter, for stoves, chimney-guards, etc.

This group of highly metamorphic rocks makes up the greater part of New England; perhaps three-quarters of its whole surface is composed of them, but the several kinds are found in very different proportions. The granitic group occupies several thousand square miles, and the schistose group an even larger area; the trappean rocks are found almost everywhere in small masses penetrating through the other groups of rocks, while the steatites and serpentines occupy the least area of any of the New England rocks, their whole surface not exceeding a few square miles.

The granitic rocks of workable quality lie principally in the eastern parts of New England, and are found in their best shape along the coast of Rhode Island and the coast lines of Massachusetts and Maine. They are the cores or centers of old mountain ranges which have been worn down to their very bases, principally by the long-continued action of the sea and the glaciers of the ice times. Some excellent granites and syenites occur also in the New Hampshire district and in central Maine. Although the granitic rocks of Scotland afford some ornamental varieties that are more beautiful than those of New England, I know of no region in the world where this class of rocks can be found in greater abundance or in more workable forms than here. It is possible in several of the syenite quarries of Massachusetts to break a single block from the quarry that shall have a length of 150 feet, a depth of 10 feet, and a width of 30 feet, the whole mass without a flaw.

The schistose rocks of this district, like those in other countries, have few qualities that fit them for any architectural purpose, and the same may be said of the trappean rocks. These old lavas in this district are invariably characterized by the presence of many joints that tend to make them cleave in various directions. These joints are readily opened by the weather, and so the rock crumbles into small polygonal blocks. This material is used only for road material, for which use the ease with which it is fractured and the great hardness of the ultimate masses peculiarly fit it. The large amount of iron oxide it contains also serves to bring about cementation of the macadamized material in the road-bed.

In the serpentines and steatites of New England we have the foundation of some small but interesting industries which promise a very great development in the future. In Massachusetts the most important localities for this class of materials are near the west end of Hoosac tunnel, and in the eastern part of the state between Lynnfield and Newburyport. At both these points a little work has been done in former years, but bad management shipwrecked the works before they obtained any considerable development.

It now remains to notice a class of building materials which has not been considered in the preceding list, viz: The drift or glacial bowlders that abound in New England. If we consider the whole of the existing walls in New England, those used for fencing as well as those in the more important foundation walls of the wooden or masonry buildings of the region, we shall find that at least 95 parts of the whole are composed of this glacial waste. Sometimes the stones, where the work is to be bound with mortar, are riven with wedges so as to give a better face for the attachment of the cement; usually, however, the stones are used without any such precaution. I know of no other district where these rude stones have been of as great service in the rough economic architecture of a country, although this use of glacial pebbles is common in other parts of America and in the glacial districts of Europe, from the lands of Scotland to the valley of the Po.

A GENERAL ACCOUNT OF THE DEVELOPMENT OF THE QUARRY INDUSTRIES OF THE DISTRICT.

Whoever has made himself acquainted with the singularly great variety of the building stones that exist in New England must in the end be surprised at the limited extent to which those resources have been applied to the arts of the country. Although the finest quarries in the country exist within its limits, there are fewer masonry houses in proportion to its wealth and population than in any other region of like extent in the world. By far the larger part of the houses are of wood, and when stone is used, save in the larger cities, it is unwillingly taken as a building material, and is generally brought from a distance, though better sorts may be close at hand. Thus in Cambridge, Massachusetts, a city of 60,000 people and of very considerable wealth, there are but a dozen stone buildings, and none in which the material has been made the basis of any considerable ornamentation. In other words, there is but one stone building to each 5,000 inhabitants. There is not a single dwelling-house of stone, not more than a few hundred of brick, and these generally of a very inferior sort. Despite its considerable cost and perishable nature, timber has remained the principal building material for dwelling-houses and shops. In the university that owns the best edifices of the city, out of about thirty important buildings only five are of stone, the rest being of brick; yet within 10 or 12 miles of the place there are many beautiful building stones, some of which have been known for half a century.

This neglect of stone as a building material may be understood after a little consideration of the history of architecture in New England. The first settlers of this country brought little wealth with them, and a love for architectural effect was the least of their pretensions. Until the rapid development of mechanical industries at the beginning of this century wealth did not begin to accumulate, or the culture to take on a type favorable for the

development of a taste in architecture. During the first two centuries timber was the natural material for construction; it was by far the cheapest material, and required the least skill for its working. Wherever architecture develops, as it had to develop here, in a plentifully wooded country the first stage of its progress gives us purely wooden edifices. All or nearly all the earliest Christian churches north of the Alps were of timber, and the houses of the common people were of the same material down to the time when timber became scarce. It is the opinion of many students of architecture that the original types of the Greek temples were also built of wood. The continuance of wood as the principal building material in New England was favored by the fact that during the first two centuries after the settlement of this country the people found themselves exposed to earthquakes of considerable severity. Those of 1685, 1727, and 1755 were of such force that, happening at the present day, they would do no small damage to masonry buildings. Many hundred chimneys in Boston were overturned. It is not unlikely that these shocks had some effect in causing the people to adhere more firmly to the old fashion of building. But the conservatism of art, in nothing so manifest as in architecture, will sufficiently explain the retention of ancient methods in the architecture of New England. During the seventeenth and eighteenth centuries there were positively no beginnings made in quarrying industries. The only quarries I have been able to trace back to the eighteenth century are some few of clay-stones near Boston. These were very small, and only furnished a part of the grave-stones, a few lintels, and a few mile-stones. Stones for cellar walls were obtained from the glacial bowlders, which were used either in their natural state or after being riven with wedges. Even down to the time of the Revolutionary war a considerable part of the grave-stones and masonry blocks were still brought from the mother country, probably as ballast in vessels that carried away timber or fish to Europe.

The first New England stones abundantly quarried were the syenites near Boston and the sandstones of the Connecticut valley. These stones began to come into considerable use in the second decade of this century. As yet these kinds of stones, with the various deposits of slate and marble that occur in Vermont and Maine, afford the only quarry materials extensively produced. The advance made in their development has been very great, and is likely to continue for a long time to come. In the present state of wealth and of taste the demand for building stones is taking other directions from those which of old led to the working of the few materials that have been brought in use. The syenites that have hitherto satisfied the needs of simple strength and cheapness in architecture have little variety of color, and an intense hardness that quite unfits them for the ordinary uses of the decorative architect. There is needed a wider range of stones for use in the decorative parts of our buildings, which shall contribute to embellishment in either of two ways: by means of their attractive colors, or by having a constitution that fits them for the use of the carver who may work them into embellishments. In the following pages I propose to call attention to the various sources of supply whence these qualities of stone may be obtained, as far as they have become known to me during the inquiries which have been made during the present census year or in the twenty years during which I have been a student of New England geology. These resources will for convenience be enumerated under the heads of the several states. It should be noted that these lists are not in any regard exhaustive accounts of materials suited for building stones, but only designate varieties and localities as far as they have found a place in my note-books or in those of my assistants, Messrs. Davis, Wolff, and Chase.

RHODE ISLAND.

The only stones of this state that have attracted my attention are the syenites, conglomerates, and limestones. The quarries in the syenites of Westerly are among the best of New England, the excellent quality of the stone being one element of their success, another being the advantageous position that these quarries occupy with reference to New York and other large markets of the sea-coast. On the point of land south of Bristol other syenites occur, distinguished by the amethystine nature of the quartz they contain. They have never been quarried for exportation, but they seem to me to offer a promising field for inquiry. North of Providence there are some crystalline limestones that are extensively worked for lime. Although these limestones have their mass extensively rent by joints, as is the case with all the limestones known to me in New England east of the Connecticut river, they may with proper search disclose some beds sufficiently free from this defect to give building stones, or at least stones suitable for certain particular uses in architecture. This region affords the best promise of such results of any known to me near the Atlantic coast.

The conglomerates of the Coal Measures are extensively developed in Rhode Island, but they have never been to any extent used for building purposes. Although they vary much in the different localities where they appear, they are generally as well fitted for architectural purposes as the similar but more ancient deposits near Boston. These rocks are abundantly exposed near Providence and at various points along the shores of Narragansett bay, whence they could be readily conveyed by ships or barges, or by rail to Boston. They seem to me to invite experiment.

MASSACHUSETTS.

In this state the variety of unused stones is very great. In the group of granite rocks a fair amount of search has been given to the field; yet some classes of this group have been entirely neglected. The blue-gray Quincy syenite having first established its reputation, all subsequent search has been given to the finding of stones

sufficiently like it to command the same market. This search has been so well rewarded that at half a dozen other points in Massachusetts good syenites of the same grade have been found, while other and handsomer stones have been passed by. These other granitic rocks occur at various points, but I shall only mention one district which seems to me to offer a profitable field for inquiry. In the ranges of hills which lie to the west of Boston, extending from Melrose through Arlington to Dedham, there exists a great variety of reddish and yellowish blotched granites or syenites that have never been quarried, and are only known to me by chance sections. I am satisfied that these stones can be found in workable masses, and, though they want that evenness of grain that makes the Quincy syenites and other similar rocks so easy to work, I believe they can be quarried without undue expense. I am sure that when polished their extremely effective colors will give them a high place among our decorative stones.

In this connection and on the same field I may note the existence of a large area of porphyrites. This field extends from Malden through Saugus and Lynn to Marblehead. These stones are as handsome and as varied in hue as those of the Mediterranean, which have furnished the supply for decorative uses to Europe for two thousand years or more. In fact, they are as handsome as such stones well can be. They have not been quarried, but it is probable that large blocks without many flaws can be obtained. The peculiar hardness of these stones, which has always been an obstacle to their extensive use, is now less of a disadvantage than of old, for the modern appliances for the use of power very much reduce the cost of working such stones. These materials are in excellent positions for working, forming cliffs of considerable height above the sea. At Marblehead neck it is possible at high tide to load the material directly from the quarry into vessels of considerable burden. This class of stones is found nowhere else in the United States in similarly beautiful forms, and nowhere else in the world, so far as my knowledge goes, in such a favorable position for exportation.

In Stoneham there are some deposits of marble that have been the object of several desultory efforts at working at various times in this century. So far all the stone found, though of an admissibly pure white color, is too much cut up by joints to be useful in the arts. Despite these failures I am not without hope that other deposits now covered beneath the mantle of drift that envelops this region may yet be discovered.

In this same section of eastern Massachusetts there is yet another source of building materials that is full of promise. I refer to the extensive deposits of serpentine that lie in the country between Lynnfield and Newburyport. This deposit has long been known to exist, and nearly half a century ago it was worked at one point as a source of supply of material from which Epsom salts were made. This serpentine has never been fairly opened save at one point, in Lynnfield, where a pit 15 feet deep has been sunk into it. From this opening some beautiful blocks of serpentine have been obtained, which show that the rock is well fitted for architectural purposes. Near Newburyport the rock seems to be more divided by joints, but it is of harder and more beautiful texture. Near Lynnfield it appears to be of a softer nature, yet not too soft for the best uses, and the blocks are of larger size than elsewhere. As yet the means of observing this deposit are too limited to afford the basis for exact statements, yet I know in America no other rock of equal promise.

In the vicinity of the east end of the Hoosac tunnel, in close geological relation with the well-known deposits of steatite that occur there, exists an extensive deposit of serpentines in which quarries have never yet been opened. The quality of the polished specimens I have seen seems very good indeed, and the deposit seems well worth a careful investigation.

I may also commend to the consideration of quarrymen the many varieties of clay-slate that occur at various points in Massachusetts, particularly near Boston. These clay-slates have long been worked for road materials, but have not been much used for construction purposes. These stones generally break well in the quarry, and are tolerably well suited for hammer-facing. Their main joint-planes are generally richly colored by iron oxide, which gives them a handsome effect in a wall. The only important edifice that has been constructed of this variety of stone is the Shepherd Memorial church in Cambridge. The cost of quarrying the stone was much less than that required for the Roxbury conglomerate, and when placed in the wall the actual cost was only about one-half as great as the conglomerate in the Mason chapel, a very similar edifice a few yards away. The distance of the buildings from the quarries where the stones were obtained is about the same. The general effect of these stones is nearly alike.

In the neighborhood of Boston there are some trappean rocks that are free from the general objection that must usually be held against New England traps in general, and which are capable of making excellent building stones. I refer to the amygdaloids of the Brighton district. These rocks occupy but a small area, not exceeding about half a square mile, yet they lie well for quarrying, the joint-planes being quite favorable for working. The color is a dark mottled green, which would seem to enliven the architecture of the structures built of the similar colored stones that prevail in this region. In the same series of rocks, apparently also of trappean nature, are some deposits of a lively green color. These are best shown near Newton Upper Falls. They seem to me to promise a useful decorative stone.

In western Massachusetts, although the district lies beyond the limits of the work specially undertaken by the survey, I may notice a few of the most important features connected with the prospective quarry industries. In this section we have none of the free-splitting granitic rocks which are so remarkably abundant in the coast

region of New England. The rocks most like them have a gneissic form that causes them to break irregularly. They were splendidly exhibited in the central portions of the Hoosac tunnel, and their extreme resistance to the action of powder as well as to the drill made that great work very costly. This rock is well exposed at the surface in the district just south of the tunnel in positions favorable for quarrying. Although it is not easy to work in the heading of a drift, such as a tunnel requires, I believe that a skillful and ingenious quarryman would manage to deal with it in an open working. The stone is extremely handsome, having the peculiar banded structure of gneiss, with a semi-opalescent quartz in large crystals. It is exceedingly resistant to transverse pressure, its structure making it, when strained across the fiber, almost as elastic as wood. It should not be used as a decorative stone in any position where it would require dressing, but it is very suitable for long lintels, and I believe it would furnish excellent edge-stones. As some of its faces are smooth it could also be had in forms suitable for rough walls, even in buildings of the highest grade.

At present the American taste is rather opposed to the use of stones that do not show the use of the hammer upon them. This is, however, a mere prejudice, for some of the handsomest structures in the world are built of undressed stones. The city of Florence, in many regards the most beautiful city in Europe, has its finest architectural triumphs built of unhewn stone. The Strotze and Pitti palaces owe to their rough stones the wonderful dignity that makes them nobler in aspect than thousands of more costly structures. When our builders accept a similar simplicity as the worthy object of their efforts it will open this class of rocks to use.

There are some good white marbles in this section that deserve more attention than has been given to them. They are somewhat worked about North Adams, but are perhaps too much jointed and of too coarse a grain to come into general favor.

After considering all the other resources in the way of building stones that are found in Massachusetts, we come again to the granitic rocks as the most extensive and surest basis of its quarry industry, and until the taste for such stones changes they are sure to be the most valuable of all its rocks.

The principal fields for these stones have already been occupied. The most important of the regions which may be designated are the Milton and Quincy district, the district of cape Ann, the district of Fitchburg, and that of Fall River. The Milton and Quincy district gave the beginning to the granite industry of New England. Its first success was great, and to this day it has more quarries within a given area than any other district in New England, or perhaps in the United States; yet it was not naturally the best locality in the New England region. As far as the quality of the stone is concerned, it is surpassed by the quarries on cape Ann and by those in Maine. The stone lies well for working, as it occupies a set of steep-faced hills divided by several valleys of considerable depth. The site is near the sea, with which it is connected by the first railway built in this country, and it is also upon the extensive railway system of the Old Colony railroad. It is thus one of the few granite-quarry districts of New England having the advantages of both methods of transportation. At present the product of this district does not seem to increase as rapidly as that of cape Ann or that of the Maine coast. The general structure of the stone appears to make the production and shipment of the stone a little more costly than in other regions. There are few large rocks now produced there, the greater part of the work being cemetery monuments and other decorative work.

Cape Ann was the next district opened to work. The quarries at that point give an excellent but little tried sort of stone. The only hinderance has been the absence of good harbors and of satisfactory railway connections. The lack of harbors near the quarries has been met by the construction of breakwaters built from the waste stone, but the provision is yet inadequate, and the cost of new harborage is too great for small capitalists.

South of Boston harbor, in Cohasset and a part of North Scituate, there are excellent sites for quarries. The stone is of a light red color, and works well, but the difficulty of harborage at the quarry point has led to the failure of several experiments in quarry work. At present the land along this shore is so valuable for villa-sites that it is not likely to be used for quarry purposes. The Fitchburg and Fall River districts, as well as the large area of granitic rocks along the line of the Boston and Albany railway, are capable of extensive development. That near Fall River is, however, the only one that is likely to secure cheap water transportation—an absolute need in the case of any new granite district seeking to compete with those already established in New England. So far the Fall River quarries have supplied only the considerable local demand. They seem to me, however, to be the best placed for extensive shipment of any in Massachusetts except those of cape Ann.

The stone in the district along the line of the Boston and Albany railway is of good quality. It is, however, of a rather gneissoid structure.

Lastly, I may notice the fitness of the abundant glacial pebbles to the construction of more important walls than those to which they have been applied. So far these stones that lie about nearly every New England field have not been much used save for dry walls or fences and for foundations. Their rounded form does not readily lend itself to the mason's use, yet by sizing the stones and using them with a little patient skill it is possible to make a strong and handsome wall from these fragments. The only considerable structure which I know that is made of bowlders is a church in the town of Medford. It is a handsome and ornamental structure, and I am told that the walls cost less than if built of any other masonry.

In the valley of the Po, in northern Italy, glacial pebbles of small size, often not exceeding 3 inches in diameter, are extensively used for building. Sometimes a frame-work of timber is first built to take the strain of the roof, and then these pebbles are built in between the timbers. In all New England these stones left by the glacial period are always very enduring, for the reason that the rough handling withstood in their making fully tested their strength. They are often very smooth, and show their natural colors to great advantage. It is to me remarkable that so simple and evident a source of construction stones has been neglected for generations in a region where good, easily-worked materials for masonry are not generally accessible. It is only to be explained by the natural conservatism of architecture, a field of activity where the penalties for rashness are often great and the profit from any one successful experiment is usually very small.

MAINE.

The building stones of this state are less known than those of any other New England state. There has been but little demand for them save for export purposes, and the distance of carriage is so great that but few of the great variety to be found there have ever been brought into use. Along the coast the limestone of Rockland and the neighborhood has long been quarried for lime, and at certain points the excellent syenite that abounds in this region has been quarried for southern markets; but nothing like a search has yet been made for the available building stones of this coast. This region is peculiarly adapted to afford a great variety of building stones. The shore is formed by the extremities of many mountain ridges, which have been planed down by the sea and by glaciers so that they no longer appear as mountains. These old mountains, which are evident only to the geologist, stood at right angles to the shore. This disposition of the rocks causes a singularly great variety of stones to be exposed at the coast-line. The harbors are numerous and deep, so that the products of the quarries can generally be loaded directly into large vessels. These conditions make this region more favorable for the development of a large quarry industry than any other region known to me in this country or in other countries.

It is much to be desired that a careful study of the stones on this coast should be made. In the meantime the following notes which have been gathered during the census, and other studies, may have a certain value as indices of the resources in the way of building stones that may be found there. Beginning at the eastern extremity of the state we may note that in the neighborhood of Calais and thence toward Perry and Eastport there are extensive beds of a very reddish feldspathic rock, probably to be classed with the granites, which deserve far more attention than they have yet received. In the town of Perry and in the towns that border upon it there are some distinctly-bedded rocks that are likely to furnish good flag-stones of fair hardness. The same may be said of the region about the winding shores of the South bay, an extensive sheet of water near Eastport. We find there many beds that would yield good flagging stones. There are some very red conglomerates in this district that might be useful on account of their brilliant colors, but they are too much jointed for the most favorable working.

Passing to the westward from Passamaquoddy bay we are for a great distance principally in granitic rocks. There are, however, many distinctly-bedded rocks of a much metamorphosed character at various points which may afford flag-stones. It is impossible to give particular localities, as the rocks have never been quarried, but the section between Lubec and Doverboro' seems to me the most promising region for search. Between Machiasport and Harrington the granitic rock is the only important material. The stone in this section, like that near Calais, is of a reddish color. Indeed, this seaward face of Washington county is characterized by the reddish tint of its metamorphic rocks, which in turn has given a reddish cast to the slates and conglomerates that have been formed from them. The best of the granites of Washington county are found in these red granites, which are probably all of about the same age. This set of rocks extends far into the interior, but they are so much more available along this shore district that it is not worth while to seek them elsewhere. I am satisfied that when the diverse qualities of these reddish granites have been determined by proper exploration it will be found that this part of Maine will afford a wider variety of these stones than any other district in New England.

Near Addison there are quarries of diabase. These rocks are commonly classed as dark-colored granites, which they somewhat resemble. The principal objection to this block granite for building stone is that in some localities it shows a tendency to decay with great rapidity. A similar stone exists near Boston, in Somerville, Melrose, and Medford, Massachusetts; but, though handsome and easily worked, it is unfit for out-of-door use, as it will often lose color in a few years and fall away in flakes. This objection does not seem to hold against the stone from this part of Maine.

Between Harrington and Gouldsboro' there are excellent exposures of granite of various colors which have not yet been quarried. We next find worked quarries at Sullivan. At this point the granite has a set of cleavages which causes it to break out in long rectangular prisms, a form peculiarly favorable for the quarryman's work. Connected with this easy breakage we have numerous slight veins in the stone that seem to make it break too easily for the best uses, and somewhat affect the color of the blocks. The rather reddish granites outcrop along the coast to the westward. On the shores of Somes sound, a deep inlet that penetrates the island of Mount Desert, there are quarries of a light red granite. Here, as elsewhere along the shore, the best quarries are found in the sides of the hills. As these hills are the parts of the rock that have best resisted erosion, it follows that they are the most solid and enduring of the rocks of the country. It may be said that throughout New England

the thickly bedded enduring rocks are in the hills, the softer and more thinly bedded in the valleys. It seems never worth while to seek for good granite in the valleys since a slight depression shows some element of weakness that makes the rock unsuitable to the quarryman's use.

Excellent granite quarries exist at the head of Bluehill bay, to the west of Mount Desert. Deer island and Vinal Haven island have exterior quarries of the same stone. On the latter island the stone splits in larger blocks than anywhere else in New England, except perhaps in the quarries of cape Ann.

On the west side of Penobscot bay there are exterior quarries in Thomaston and Saint George, near Richland. West of the Penobscot the quarries are not limited to the coast line, but some are situated on the Kennebec, at a distance of 60 or 70 miles from the sea. This is not because the granite is particularly better or more abundant there than in the inland region of the Penobscot, but because there is more local demand for stone and the means of shipment by railways are much greater. There are also considerable quarries of roofing slates in this section of the state west of the Penobscot river; they lie, however, much north of the belt of granite quarries. The granitic character of the coast is continued to the New Hampshire line, and the numerous small and a few large quarries attest the general goodness of the stone. It will be noticed that the only building stones quarried along the coast of Maine are granites, or crystalline rocks closely related to them. It must not, however, be supposed that no other kinds of stone occur along this coast. The limitation of the production to this single quality of stone is to be explained in part by the fact that this stone is the only one for which there is an extensive market, and the search has naturally been first made for it. Even more, however, must be attributed to the fact that the continuation of marine and glacial erosion which has gone on upon this shore has worn away almost all the softer rock exposed to its action. The larger part of the limestones, slates, sandstones, etc., that find their geological position on the folds along this coast have been so worn away that they lie beneath the surface of the deep indentations of the sea which are so conspicuous here.

These granitic quarries afford very excellent conditions for working. The stone opens easily, having the peculiar inchoate joints that are such striking features in the syenite or granite of New England. There are generally at least two of these rift-lines. Then there is a more or less complete division by what appear to be true beds, as well as joints, so that the division of the rock is as complete as could be desired. At the same time the lines of weakness in the rock are not so numerous as often to make the quarried masses too small for use, as is sometimes the case in other districts. The impurities in the way of spots and veins, which often seem to mar the appearance of granitic rocks, are not found in any great abundance save at a few points. Added to these advantages this shore affords a frontage in its islands and inlets of not less than 2,000 miles, the larger part of which lies in workable granite or kindred rocks, though of course not always of the best kind.

Although the extreme erosion has left little of the more wearable rocks along the coast-line of Maine, the inland regions seem likely to yield a good variety of stones. The principal trouble at present is that the coating of forest and the layers of drift mask the greater part of the surface, except where the very hardest rocks occur.

MACHINERY AND LABOR.—In the larger New England quarries steam cranes or derricks are generally used to move the stone to the carriage that carries it away from the quarry heading. In the smaller quarries the hand-crane alone is used. These cranes are generally conveniently arranged for their work.

In the latter class of quarries wagons for conveying the stone to the shaping- or dressing grounds and to the shipping grounds are no longer employed. The road out of the quarry is generally occupied by a tramway, and locomotives, generally of the light dummy pattern, are used to drag the carriages to the shipping-point or to the dressing-grounds.

From a considerable knowledge of the European quarries I believe that the amount of manual labor used in their quarry work is at least twice as great as that required in the better class of American stone pits. The result is that we can furnish rough stone at a lower price than that at which it can be produced in Europe, despite the higher paid labor here. In the treatment of the stone after it leaves the quarry the American methods show no advance upon those of Europe; and it is in this part of the work of preparing building stones that the cost most rapidly increases. The wages for all sorts of hand-work in dressing are very dear, and so far little effort seems to have been made to replace these methods by mechanical contrivances. When stone is to be dressed into ornamental shapes it does no seem practicable to gain much by any mechanical processes; but when the aim is merely to polish the flat face of the stone or to bush- or face-hammer them, it ought to be possible to replace hand-work by automatic machinery. One reason why more effort has not been made in this direction is doubtless that mechanical power derived from steam is generally costly in the quarrying districts of New England. This may perhaps be met by the use of tidal water-powers that abound along all this coast-line. These water-powers can often be brought into use at a very small cost for plant, and as they do not depend on drought, and generally involve no damages for flowage, they will be much cheaper than fresh-water power. Their general utility is sufficiently proved by the frequent use made of them on this shore for ordinary milling purposes.

TRANSPORTATION.—The carriage of the quarried stones to market is generally effected by rail or water. The quarries near the sea-board have a great advantage over those upon the railways, inasmuch as they can ship at much less cost, the carriage by sailing-vessel being only a small fraction of that which must be charged by railway. On these vessels the stone is generally laden upon the deck, except the smaller sorts, such as paving stones, which are

stored in the hold. It seems to me that vessels of the sort known as catamarans, *i. e.*, those with two distinct bodies, with a pavement covering the whole, would make safer forms of ships for this carriage, as it is the heavy deck burden that makes an ordinary ship very top-heavy and liable to accidents.

GENERAL RELATIONS OF NEW ENGLAND BUILDING STONES TO THE MARKETS OF THE UNITED STATES.

It is worth while to notice the general relations of the New England quarry industries to the rest of the country, as we may thereby gain the basis for a forecast of their future.

A glance at a geological map will show that the rocks that characterize New England are not found in an equally extensive development in any other district south of the Saint Lawrence and east of the Rocky mountains. The same highly-metamorphosed series of rocks is continued in a less extensive way south along the whole chain of the Appalachians as far as northern Alabama; but it leaves the sea-board region at New York, and south of that point is not readily accessible to tide-water navigation. Moreover, when we get even as far south as New York we find that, owing to the progressively less and less considerable development of glacial action in southern regions, the rocks show the effect of decay to a much greater depth than they do in New England, where the last glacial period stripped away all the incoherent decayed portion of the rocks, leaving only that which was well suited to the use of the quarryman. The result is that even near New York, and in a greater degree for every step eastward, the stone is decayed along the joints to such an extent that we can rarely find good solid blocks within from 20 to 50 feet of the present surface. This deep "cap" of decayed rock is a serious hinderance to the development of good quarries of crystalline rocks in a large part of the southern Appalachian mountains.

These two advantages, the neighborhood of the crystalline rocks to the sea and the absence of any worthless decayed upper part, will always give the New England rocks of the granitic group a very great advantage over those of any other part of the eastern United States.

It should also be noticed that the cost of quarrying granite of good quality is perhaps less than that of any other work of the same general utility, certainly much less than the cost of our other principal building stones, so that, for all large structures where rude strength is the only need, quarries of this stone are always likely to be at a great advantage in production.

There are no other sources of supply of granite that are ever likely to compete with this stone district of New England. The same qualities of stone are found in southern Nova Scotia with the same advantages of quarrying: but this region is on the average several hundred miles farther from the principal points of consumption, so that the tax due to distance will always amount to about as much as the present profits of the New England quarries. The cost of carriage on a ton of stone from Nova Scotia above that from cape Ann, supposing the distribution to be to New York or Philadelphia, is at the present low rates of freight about 50 cents. This is probably more than the average profit that is made upon the stone itself. Thus there could be no effective competition save for such stones as have been carved or finished, so that the actual value bears a very large proportion to the original cost of quarrying and conveying to market. It is quite clear, therefore, that the position of the New England granite quarries is particularly favorable, and that they are likely to command the market for cheap stones for a great while in the future.

The same may be said, though in a less emphatic way, for the other building stones of this region. The roofing slates, particularly those of Maine, the exploration for which has hardly begun, are very well placed for marketing, as they have the same advantage, arising from the small amount of waste rock on their surfaces, that the granite quarries have. The slates have rather more drift matter upon them than the granite quarries have for the reason that they generally lie in rather lower ground: still this drift is loose material requiring no other than pick and shovel work before the profitable work is attained. In Maine, especially, these quarries lie near enough to tide-water to share the advantages arising from their method of carriage, being not more than from 30 to 60 miles away from the nearest tide-water navigation.

There are no certain supplies of good marble within a remunerative distance of the shore-line of New England, the nearest approach thereto being the extensive deposits of serpentine rocks that lie in Middlesex and Essex counties, Massachusetts. Between Lynnfield and Newburyport there is an extensive deposit of this character that will afford a material suitable for the carver's art.

I am not without hope that it will be possible to find some marbles suitable for building purposes in Rhode Island or in Maine, and it is greatly to be desired in the interests of American architecture that more good carving stones should be brought into market. Though New England abounds with excellent and beautiful construction stones, it leaves much to be desired in the way of stones fitted for the work of the sculptor. None of its marble is really fit for the best statuary purposes.

DETAILS REGARDING QUARRIES

MAINE.

[Compiled mainly from notes of John Eliot Wolff.]

The Red Beach granite is quarried near Red Beach, Jonesboro', and Calais, Washington county, is used principally for monuments, and to some extent for general building purposes. It is quite largely used for polished columns. The principal markets are Boston, Providence, New York city, Baltimore, Philadelphia, Buffalo; Cincinnati, Cleveland, Zanesville, and Columbus, Ohio; Springfield and Chicago, Illinois; Milwaukee, Saint Louis, Saint Joseph, Kansas City; Charleston, South Carolina; Wheeling, West Virginia; Washington, District of Columbia, and San Francisco.

In the Red Beach quarries there are two sets of principal joints, both nearly vertical, which seem to be continuous through the granite of this region. The finest set has a direction S. 55° W., and the other 65° E. There are also some less regular cut-off joints running S. 60° W. and slanting east. The sheets are fairly regular, running from 7 to 4 feet and less; the jointing is remarkably regular for granite, and the almost rectangular intersection of the vertical joints gives the blocks a cubical and rectangular form rare in granite. The stone is free from blemishes as seen in the quarry. Little quartz veins and black concretions (one of which when tested appeared to be principally magnetite of small size) are the principal ones. The rift of the stone is parallel to the S. 65° E. joints. On the surface rock this stone weathers with a snow-white appearance. The feldspar, both red and dirty white in color, turns to a dazzling white, the quartz remaining unaltered, while the mica and magnetite and other minerals become inconspicuous. The granite-workers here are very largely Aberdeen Scotchmen, and some of the polishing-machines are adapted from Scotch models.

The stone compares very favorably in appearance with the Peterhead Scotch granite and the Nova Scotia red granite. The rock is a biotite granite, is a good working stone, and quite hard and brittle, taking a high polish. Blocks 7 by 7 by 2 feet thick have been shipped, and blocks 30 by 15 by 2½ feet might be quarried.

The columns of the court-house at Providence, Rhode Island, and those of the custom-house at Kansas City, Missouri, the Centennial block at Portland, Maine, and a portion of the basement of the custom-house at Fall River, Massachusetts, are of this stone.

At Jonesboro' the quarries are shallow and extend over a comparatively broad area on the top of the hill on which the quarries are situated. The sheets thin out, but deepen on going downward. There seems to be but one good set of joints, standing nearly vertical and running north about 80° east. The rift of the stone does not seem to have a very determinate direction, but approximates to a parallel with these joints. The grain is horizontal, the sheets become thicker at the bottom of the quarry, and run from 5 to 3 feet and less in thickness. The stone splits well and straight in any direction, and by drilling and wedging rectangular blocks are obtained. Both light and dark patches appear in the stone.

The greatest defect of the stone, which causes considerable "grout", is the frequent occurrence of red stripes or veins of red feldspar crossing the stone. Some of these stripes appear to be small, very tight seams, along which the stones have become sappy, giving the red color. Veins or dikes of fine red granite run through the quarry in one or two places; often the tongues running out from these are red on the outside and white inside, resembling the patches in appearance. This belt of red granite is locally thought to be continuous with that found at Red Beach, on the eastern edge of the county, and also to cross into New Brunswick and form the Macadare red granite, becoming redder toward the east. Wellington Brothers' building, Boston, and the Hunnewell building, New York city, are among the buildings in the construction of which the Jonesboro' red granite was used.

The trap dikes in Washington county, furnishing white and black granite, properly a diabase or olivine diabase, are quarried chiefly for monumental purposes and shipped to New York city, Brooklyn, Boston, Washington, Montreal, and Quebec. It was used to some extent in the construction of the inclosure-walls of the Capitol grounds, Washington city, for a bank in Montreal, and extensively for monumental purposes in Greenwood cemetery, Brooklyn. Blocks 15 by 10 by 20 feet have been moved in the quarries, and natural blocks 90 by 10 by 15 feet occur. Six miles southeast from Madison point, on Pleasant river, one of the principal quarries in this rock is located; it is a remarkably favorable location, being at the water's edge, and the waste is easily used in extending the wharf. The stone is extremely hard and takes a good polish. The principal defects causing the waste stone are the so-called "knots", consisting of irregular patches of very coarse, white feldspar, mixed with fine, large, black hornblende crystals; little seams also occasionally split off part of a block, but the stone usually presents a uniform surface, free from the frequent patches and other irregularities of ordinary granite. The stone seems to weather remarkably well for one containing so much hornblende. This quarry is called by the quarrymen a "block quarry"—that is to say, the horizontal or concentric sheets of ordinary granite are few. There are two sets of vertical sheets, the best run due east and west and give blocks, as far as the quarry has been developed, from 15 feet down in length. There are also north and south vertical joints less perfect, but more frequent than the others. The rift or easiest splitting direction runs parallel to the east and west joints; the grain, or next easiest, north and south, while the lift or horizontal splitting is hardest of all. Hence the natural blocks are approximately rectangular in shape.

Near West Sullivan, Hancock county, a light gray biotite granite, sometimes having a pinkish tint, is quarried for general building purposes, for paving and curbing, and is employed to some extent for monuments. The principal markets thus far have been Boston, New York, Brooklyn, Albany, Philadelphia, Washington, and other places on the Atlantic coast accessible by water transportation. Blocks 25 by 25 by 2 feet thick have been quarried: the sheets of stone vary from 6 to 3 feet in thickness and have a slight dip to the north. The rift of the stone is, as the quarrymen express it, "on the lift," that is, horizontal or parallel to the sheets, and this is usually the case in the Sullivan granite region. The grain is vertical, running S. 70° E., and has a remarkably straight and plane cleavage, so that the stone frequently comes out in long rectangular prisms. It may be said here that these beautiful cleavages are among the characteristics of the Sullivan granite and are of great advantage in making paving blocks, as the blocks are shaped from the material with ease, a few slight blows often sufficing to reduce the stone to a proper shape. There are also vertical joints running across the grain S. 20° W. The principal defects are the black patches, and some of the stones have very thin seams called by the workmen "pencil-mark" seams, from their appearance; these are an element of weakness.

A mile north of West Sullivan is located a typical sheet quarry, the sheets running from 2 to 6 feet in thickness, having a very smooth almost plain though gently-curved surface, dipping slightly to the northwest. Vertical joints are few. The rift is on the lift, or parallel to the sheets, and the grain is vertical. There are some large vertical joints running through the quarry; some of the quarrymen distinguish seams running across the grain obliquely as "grain" seams; seams oblique to the grain as "tight" seams, and certain seams coated with decomposed feldspar as "chalk" seams. There are several very large black inclusions seen in the granite.

A quarry producing excellent splitting stock is situated three-quarters of a mile north of Sullivan. The sheets run from 7 down to 3 feet in thickness. There are some large vertical joints running northeast occasionally filled with trap dikes. The stone has a somewhat conchoidal fracture and shows the usual black patches. The rift is parallel to the sheets, and the grain runs east and west at right angles with the vertical jointing.

Near Franklin, Hancock county, a light gray, massive, biotite granite is quarried for curbing, paving, and cemetery work. The principal markets are Boston and New York city. The texture of the stone is medium fine and porphyritic. Blocks 30 by 14 by 3½ feet thick have been quarried.

On Somes sound, 2½ miles south of Somesville, Mount Desert island, Hancock county, a light gray, massive, biotite granite is quarried for general building purposes, bridge construction, and paving. The stone was used in the construction of the Brooklyn approaches and towers to the East River bridge, and in the arches and foundations, and the new bridges in Back Bay park, Boston. Blocks 150 by 50 by 18 feet thick have been loosened in the quarry. The position of the quarries on Mount Desert island is peculiarly good for shipping, as they lie near the head of Somes sound along a narrow and very deep fiord, running several miles inland from the southwest harbor, between the mountains. One of the quarries is situated on the side of a hill and at the water's edge. The sheets of stone are very thick in some cases, one being 18 feet in thickness. The sheets have a steep dip from the summit of the hill down to the water's edge. There are a few north and south vertical joints or headings, usually not less than 60 feet apart. The rift is on the lift of the sheets, and the grain as usual is parallel to the great north and south joints. In connection with the dip of the sheets away from the hill, considerations concerning the form of the granite hills of New England suggest themselves. It is held by some that these hills have been rounded into their present shape by ice, while others believe that their form is due to the structure of the granite.

In Maine not only are the quarries of great extent and depth, and generally located on hills, but these are generally sufficiently bare of vegetation to conceal the outline. Many of the larger quarries of Maine are sheet quarries, and in every case where vertical joints are not present, breaking up the sheets to such an extent as to conceal their direction, the round form of the hill is plainly seen to be due to the gentle curve of the sheets.

Two miles south of Somesville there is a granite quarry, the opening of which is yet shallow, and the sheets are consequently thin. The rift is on the lift and the grain is approximately east and west: the infrequent joints are mostly north and south.

Near East Bluehill, Hancock county, a light gray, sometimes pinkish-gray, massive, biotite granite is extensively quarried for general building purposes and for paving. It has been used in the construction of the city hall (trimmings), the art gallery in Fairmount park, and the Pennsylvania Railroad bridge, Philadelphia; in the East River bridge, New York city; the post-offices in Chicago and in Harrisburg; and the Thomas monument in Washington city. In texture the stone is medium-fine porphyritic. Blocks 90 by 80 by 6 feet have been moved in the quarry; a block of 80 tons was loosened and moved out some feet in one of the quarries. It is a compact, good, safe, and free-working stone, and takes a good polish. Specimens were tested at the centennial exhibition at Philadelphia which showed a crushing resistance of 19,000 pounds to a 2-inch cube. The quarrying here has been to a considerable extent done on the surface, although there are some large openings. The stone lies in sheets, often irregular, from 3 to 10 feet in thickness, and the jointing is sometimes irregular in many of the openings. In one of the quarries there are sheets 9 feet in thickness, though the usual thickness is from 1 to 5 feet. The stone contains a few black patches, the joints are not frequent, and their direction when present is east and west.

In another quarry the sheets are from 6 to 8 feet in thickness, the dip steeply southeast; the rift is east and west with the dip of the sheets, and the grain north and south. The vertical jointing is irregular; patches and occasional veins of white granite are present. At another opening the sheets reach a thickness of 20 feet; the long seams cut down through the mass, but are usually far apart.

Near Deer island, Hancock county, a light gray, indistinctly-laminated biotite granite is quarried for general building purposes, bridge construction, and paving. It has been used in the construction of the Broadway bridge, South Boston; base of columns of elevated railroads in Brooklyn; and grain elevator of the New York Central railroad, New York city. Blocks 14 by 8 by 20 feet have been loosened in the quarries, and the dimensions of some of the natural blocks are as much as 150 by 15 by 15 feet. It is a compact, good, safe, and free-working stone, and takes a good polish. The sheets in one of the quarries reach a thickness of 18 feet, though the usual thickness is from 6 to 12 feet. They extend into the hill nearly horizontally, and are intersected by occasional vertical joints. The rift here is vertical, running north and south, parallel to the joint; the grain at right angles, or east and west.

In another opening the stone lies in very thick and broad sheets, nearly horizontal, with a slight dip toward the water; the sheets are from 6 feet downward in thickness, and are intersected by a few joints. The rift here runs north and south, and most frequent vertical joints also run north and south.

Another quarry in this vicinity lies in a steep hill, the slope running down to the water's edge. Where they are now working the sheets average 3 feet in thickness, the maximum being 5 feet and the minimum 1 foot. The dip is very steep from the top of the hill to the water's edge. There are few vertical joints; the rift runs best toward the top of the hill. At the north end of the quarry the sheets are horizontal, of great thickness, one being over 20 feet thick, and having considerable length and width as well.

In another of the principal quarries the sheets occasionally reach a thickness of 20 feet; the vertical joints have an east and west direction, and are found at intervals varying from 5 to 60 feet.

A mile and a half south of Frankfort, Waldo county, a gray, massive biotite granite is quarried for general building purposes, bridge construction, monumental, paving, and polished columns. It is sent as far as Mobile and New Orleans. It was used in the construction of East River bridge, New York; basement of the State, War, and Navy building, Washington city; art gallery at the centennial exhibition, Philadelphia; art museum, Central park, New York city; Saint Louis bridge across the Mississippi river; pedestal of the statue of Admiral Farragut, Washington city; forts Knox, Popham, Gregg, Preble, Schuyler, Constitution, and other fortifications. The texture of the stone is coarse and porphyritic. Blocks 80 by 40 by 20 feet have been moved; a block of 30 tons was cut and shipped. It is estimated that blocks 150 by 50 by 12 feet might be moved in the quarry. The principal quarry is situated on mount Waldo, overlooking the Penobscot river, and at an elevation of some 320 feet above high tide. It is a situation allowing of easy disposition of the waste; the stone lies in immense sheets dipping off from the mountain, varying in thickness from 1 foot to 20 feet, the usual thickness being from 4 to 5 feet. The quarry is traversed by frequent head joints running S. 75° E., but there are comparatively few joints at 90°.

The rift is on the lift, or parallel to the sheets; the grain runs S. 75° E., or parallel to the headings. Two varieties of stone are obtained—coarse and fine; the local impression is that a belt of fine granite runs through the coarse prevailing granite. This stone was used in the construction of many of the eastern forts before the late war, but a year or so of the war demonstrated the comparative inferiority of stone for this purpose and caused the building of stone forts on the Atlantic coast to be discontinued, and the business of several of the Maine quarries was for a while diminished through this cause.

Near Prospect, Waldo county, a gray, massive biotite granite is quarried to a limited extent for street work, sills, heads, platforms, and bridge construction. It was used in the construction of the railroad bridge at Bangor, and in the East Boston dock. The texture of the material is rather coarse; the stone lies in sheets, and the rift is on the lift; there are two sets of joints. Blocks 6 by 4 by 4 feet have been shipped, and blocks 30 by 35 by 10 feet might be moved in the quarry.

Near Swanville, Waldo county, gray biotite granite is quarried for cemetery work, paving, platforms, and columns. The principal markets are New York city, and Boston and Quincy, Massachusetts. It was used in the construction of a soldiers' monument at Buffalo, New York. Blocks 20 by 9 feet by 1 foot and 10 by 10 by 2 feet have been cut, and blocks 40 by 20 by 2 feet might be moved. The stone here is uniform in texture, free from blemishes, and is a compact, good, safe, and free-working stone, taking good polish, and lies in regular sheets varying in thickness from 1 foot to 4 feet. The quarry is located on a hill, and has not as yet been developed to any great depth. The rift is vertical, and runs north and south, the grain east and west; the vertical joints cut through the quarry east and west parallel to the grain.

At Lincolnville, Waldo county, about 6 miles west of Camden, a very light gray, massive muscovite-biotite granite is quarried to a limited extent for underpinnings and local stone-work generally. Thus far it has been used only in Camden and vicinity. Blocks 12 by 2 by 6 feet have been quarried; blocks 50 by 25 by 6 feet might be moved. This stone has a good appearance, is uniform in texture, and is a good, safe, and free-working stone, taking good polish. It does not lie in sheets, but rather in blocks. There are frequent vertical joints in one direction. The rift is vertical and about parallel to the vertical joints. The quarry lies near the base of a mountain near Camden, but it is small and not worked regularly.

The extensive quarries at Vinal Haven, in Knox county, produce granite for general building purposes, monuments, and paving. It was used in the construction of the East River bridge; half of the Masonic temple, Philadelphia; Sailors' Snug Harbor, Staten island; half of the railroad bridge at Saint Louis; basement of the State, War, and Navy departments, Washington; custom house and post-office, Cincinnati; polished work in Chicago court-house and city buildings; part of polished work in Philadelphia city buildings; a portion of the basement and quadrangle of the Patent Office building, Washington city; the Butler monument at Greenwood Cemetery mausoleum; and smaller monuments in various parts of the country. The color of the predominating material in these quarries is light gray; the texture is medium coarse. There is a dike of trap in one of these quarries, producing what is locally called "black granite", and used to some extent for building material. In what is known as the Harbor quarry the rift is very good, and is vertical, having a direction east and west; there is a very frequent vertical jointing in this same direction, giving long, narrow blocks; north and south joints are less frequent. The sheets vary from 3 to 8 feet in thickness, and immense masses of stone entirely free from joints occur.

The Sands quarry, adjoining the Harbor quarry, is bounded by two sets of great vertical head joints, running respectively northwest and southeast, and the easiest rift is vertical, parallel to these joints. In the center of the quarry there are not many joints; the sheets average from 4 to 5 feet in thickness, but some are 7 and 8 feet thick; they have a slight dip west, with quite smooth surfaces. The obelisk sent from this quarry to serve as a monument to General Wool, at Troy, New York, is said to be the largest quarried in modern times. Its dimensions are 60 by 5 by 5½ feet. Four long blocks were quarried before a satisfactory one was obtained; one of these lies on exhibition near the quarry. Natural blocks 240 by 32 by 8 feet can be seen in the quarries. Occasional black micaceous patches occur in the stone, which, together with vertical dikes of light-colored stone, constitute the principal defects seen. The East Boston quarry is a sheet quarry of fine-grained stone, the sheets running from 2 feet downward, and dipping slightly east. The rift is horizontal; some long east and west head joints traverse the quarry, but between these the jointing is irregular. The stone has been most used for paving and platforms.

In a quarry at Duschane there are vertical joints running regularly through the quarry at intervals of from 7 to 10 feet, in an east and west direction, and, as the grain of the stone or next easiest rift runs north and south, the blocks come out in rectangular shape. The rift is vertical and parallel to the east and west joints. The hardest splitting direction is on the lift, or parallel to the sheets, and the sheets are irregular. In one case the vertical thickness is 12 feet. The material has a pleasing appearance and is now used for polished work.

In the town of Vinal Haven there is a very small granite quarry, in which the structure of the stone is such as to be a very convenient source of paving material. The stone is extremely good, occurring in regular sheets of from 1 foot to 3 feet in thickness and nearly horizontal. There are occasional black patches; some long east and west vertical head joints bound the quarry, and there are also a few north and south joints. The peculiarity of the stone is its beautiful and even rift, and paving blocks may be shaped from it by a few blows of the hammer.

At Hurricane island, three miles southwest of Vinal Haven, a dark gray granite, sometimes having a pinkish tint, is quarried for ordinary building purposes, monuments, columns, and paving, and has about the same markets as the other Vinal Haven quarries. The stone was used in the construction of the following buildings: All the superstructure of the new post-office and custom-house, Saint Louis; the basement of the new city hall, Providence, Rhode Island; superstructure of the post-office at Fall River, Massachusetts; polished columns of the Chicago city hall and court-house; portion of the Indiana state-house, Indianapolis; Douglas' tomb, Chicago; and numerous monuments at Saint Louis. The structure of the stone differs in different parts of the quarry. In one portion it lies in comparatively thin sheets, while in another there occur immense masses of solid stone extending 50 feet downward without any perceptible jointing. A block of 80 tons has been moved, and a shaft was produced 23 feet 6 inches by 3 by 3 feet, when dressed, and a mass 80 by 40 by 25 feet was loosened in the quarry, and natural blocks 500 feet long, 20 feet wide, and 50 feet deep occur. The east rift runs east and west, while the grain or next easiest splitting direction is horizontal. The principal joints run east and west, but there are occasional north and south joints.

Three miles north by west from Vinal Haven granite similar in appearance to the Hurricane Island granite is quarried for similar purposes. It is used to some extent in the construction of the Brooklyn bridge, Chicago post-office, and the Raymond jail, in Brooklyn. It is a very superior sheet quarry; the stone lies in very smooth, slightly-curved sheets, having a thickness from 5 feet downward, averaging 3 feet. The sheets have a gentle dip to the west, or toward the water. Vertical joints are found in either direction, and the sheets are smooth, so that the stone is eminently fitted for large platforms. The rift is on the lift; the principal defects are patches, which occur occasionally.

At Muscle Ridge plantation, Dix island, Knox county, a dark gray granite was, until recently, quarried for general building purposes and ornamental work, but the quarry is not at present operated. Among the buildings in the construction of which this stone was used are the New York post-office and custom-house, docks at Castle Garden, and retaining-walls for basin and barge office, New York city; Dennmore fort, Hyde Park, New York; Philadelphia post-office; Treasury building (extensions), Washington city; and basement of custom-house, Charleston, South Carolina. Nearly the whole of Dix island has been quarried over, large bluffs having been entirely removed, and

deep excavations contain over 50 feet of water. The rift of the granite here is on the lift, the jointing irregular. Blocks 17 by 17 feet, and of varying thickness, sometimes weighing as much as 72 tons, have been quarried; natural blocks 25 by 25 by 15 feet may be seen in the quarries. The stone is coarse, porphyritic, and indistinctly laminated or massive. Specimens dressed at the National Museum proved to be of more than usual hardness and took a good polish. Steam-drills are employed in the quarrying.

At South Thomaston, Knox county, at Spruce Head island, 8 miles from Rockland, a dark gray granite is quarried for general building purposes, bridge construction, and for monumental work in the cities throughout the country. Among the structures in which this stone has been used are the Albany, New York, post-office (first story); post-office and court-house at Atlanta, Georgia; forts at Portland, Maine; in the East River bridge, New York, and in the Philadelphia city buildings.

One of these quarries at Spruce Head, known as the Bodwell quarry, which has furnished so much building stone to the coast of New England, is in the form of an excavation, commenced at the water's edge and pushed far into the hill, where it reaches a great depth. It is a sheet-quarry, the sheets increasing in thickness downward, and the thickest ones now exposed are from 9 to 10 feet in thickness, and show superb masses of stone. The sheets incline slightly away from the hill with gently undulating surfaces. There are few vertical joints, almost the only ones having a north and south direction, and the east and west headings run through the quarry, forming the boundaries on some sides. The rift of the stone is vertical, and east and west, nearly parallel to the head joints. The Spruce Head granite has established a good reputation for its quality of resisting weather exposure and retaining its color. The greatest defects have been the black patches which are conspicuous on a bushed surface. There seem to be fewer of these patches in the present deep sheets.

The Sawyer quarry, adjoining the preceding, is similar. The stone lies in very regular and nearly horizontal sheets, varying from 3 to 12 feet in thickness. There are few vertical joints; but there are two sets of large head joints running respectively north and south and east and west. The rift here is reported as being horizontal, or on the lift, which, if true, is remarkable, since it is vertical in the quarry immediately adjoining.

In the Jameson quarry the stone lies rather irregularly in sheets. There are nearly vertical north and south joints; also east and west seams, to which the rift is parallel. The stone has very few blemishes, and specimens dressed at the National Museum were compact, safe, and free-working stones, taking a good polish. The quarry is drained by means of steam-power, and steam polishers are used in dressing.

Near Saint George, Knox county, there are granite quarries extensively operated for general building purposes, monuments, columns, and paving. The following are among the structures in which the stone has been used: Buffalo city hall; United States custom-house and post-office, Hartford; national bank, Albany; government storehouse at League Island navy-yard, Philadelphia; entrance to Chicago post-office; entrances to Utica, New York, post-office; Albany post-office and custom house above the first story; McClintock's building (trimmings), Pittsburgh; pedestal of the La Fayette monument, Union square, New York city; post-office and custom-house at Portland, Maine. This stone is of comparatively fine texture and is sometimes indistinctly laminated. It is a free and safe working stone, taking a good polish. Blocks 30 by 12 by 8 feet have been loosened and moved in the quarry, and natural blocks 75 by 60 by 6 feet exist.

Of the three principal quarries the Long Cove quarry has large parallel joints traversing it S. 70° E. from top to bottom at intervals of from 1 foot to 20 feet, and there are sheets of greater or less depth, so that natural blocks have a somewhat rectangular form. The grain is parallel with these joints. The hoisting is done by steam, dressing by hand, and steam polishing-machines are used in dressing.

In the Clark's Island quarry the arrangement of the stone is in sheets from 6 inches to 15 feet in thickness. The sheets have a gentle and sometimes slightly irregular dip toward the water and away from the crest of the hill. The easiest splitting directions are horizontal and parallel to perfectly vertical joints, which traverse the quarry at intervals of 6 feet and upward.

In the Wild Cat quarry the sheets are thin and rather irregular. There are south and east vertical joints, and the rift is parallel to them.

Four miles east of Saint George there is a quarry which was opened in 1879. Blocks 20 by 10 by 7 feet have been moved in the quarry, and natural blocks about 90 by 30 by 6 feet exist. The granite in the Saint George quarries varies from a light gray biotite granite to a hornblende-biotite granite, which is usually darker in color than the other. Hoisting is done by steam, and cutters, polishing-machines, and circular saws are used in dressing.

One and a half miles west of Waldoboro' is a small quarry the product of which has been used in small quantities in the neighboring towns for underpinnings, steps, posts, bases, and to a limited extent for cemetery work. The stone lies in moderately regular sheets varying from 2½ to 7 feet in thickness. The rift is horizontal and the grain runs northwest. The quarry is quite free from vertical joints and could be made to yield large masses of stone. Blocks 40 by 10 by 4 feet have been loosened, and blocks of perhaps 100 by 30 by 3 feet exist in the quarry. The stone is a fine-grained, indistinctly-laminated biotite granite.

At Jefferson, Lincoln county, 9 miles north of Butter Neck bridge, on the Knox and Lincoln railroad, there is a quarry operated to a limited extent chiefly for monuments and cemetery work. The dressing and polishing of the stone are done at Waldoboro', by water power, and the material is transported to this place by water. Although

called granite commercially, it is more properly a muscovite-biotite gneiss, of a light gray color and fine in texture. Blocks 10 by 20 by 2 feet have been quarried, and natural blocks as large as 20 by 10 by 2 feet are found in the quarry.

Half a mile east of Round Pond and 9 miles south of Damariscotta, Lincoln county, granite is extensively quarried for monumental and for building purposes. Among the structures in which the stone was used are the Seventh Regiment armory, New York city, and several monuments to Admiral Parrott in New Hampshire. The stone in this quarry for 20 feet down is much broken by joints and sheets from 1 foot to 2 feet in thickness. There are frequent vertical joints having a southwest direction, and others at right angles with these occur, but are less frequent, and the grain of the stone is parallel to them. The rift is on the lift, or horizontal. A large dike crosses the quarry parallel to the southwest joints, and large veins of granite coarser in texture than the predominating material occur. The most common rock of this region is gneiss, which outcrops in straight parallel lines after the manner of roofing slate. The gneiss is very curiously interbanded with a massive or gneissoid granite. This is illustrated in the quarry where bands of contorted gneiss, worthless for building purposes, run to the surface at a steep angle in the massive granite quarried. The quarry is so broken up by the irregular sheet-joints and mineralogical accidents that the waste of stone has been very great, and but few large blocks can be quarried at present. The dimensions of the largest block quarried here are 15 by 2 by 2 feet, but blocks about 6 by 6 feet by 1 foot 6 inches may now occasionally be obtained. The material is a dark gray biotite granite, and is a compact, free-working stone, taking a good polish.

Near Augusta, Kennebec county, granite is quarried largely for local use, but some is shipped to New York, Brooklyn, Philadelphia, Boston, and Chicago. The following are some of the structures in which it has been used: The United States arsenal, Cony academy, and a Unitarian church in Augusta, and the Old South church in Hallowell; Mills' building, corner Broadway and Exchange street, and a monument to Recorder Hackett, New York city; Roberts' tomb in Woodlawn cemetery, Long Island; Wood's tomb, Greenwood cemetery, New York. The material is a gray muscovite-biotite granite, massive and of fine texture, is a compact, safe, and free-working stone, and takes a good polish. Blocks 40 by 9 by 2½ feet have been loosened; blocks 20 by 2½ by 2½ feet have been dressed and shipped, and natural blocks 100 by 30 by 7 feet are found in the quarry.

In a quarry 2 miles west of Augusta the stone lies in sheets from 9 feet in thickness downward; east and west head joints traverse it, and the rift is horizontal.

In a quarry 1 mile west of Augusta the rift is on the lift, the grain vertical, having a northwest direction, and the material lies in very regular sheets, usually not over 2½ feet in thickness.

Half a mile to the eastward of this the stone resembles that at Hallowell, and lies in sheets of 1 foot in thickness, with northwest vertical joints.

Near Hallowell, Kennebec county, is a well-known quarry, producing granite very extensively for monuments, columns, trimmings, and general building purposes. Among the structures in which this stone was used are the new capitol, Albany, New York; the Bank of Northern Liberties, Philadelphia; the state capitol and Allen block, Augusta, and the Emery block, Portland, Maine; Odd Fellows' Memorial hall, Equitable building, and part of the old Quincy market, Boston; Ludlow Street jail, the *Tribune* building, and the old Tombs prison, New York city; the statues of the Pilgrims' monument, Plymouth, Massachusetts, said to be the largest statues in the country; the soldiers' and sailors' monument, Boston, and soldiers' monuments at Marblehead, Massachusetts, Portsmouth, Ohio, and Augusta, Boothbay, and Gardiner, Maine; Odd Fellows' monument, Mount Hope, Boston; monuments to General Stedman, Hartford, Connecticut, and Stephen A. Douglas, Chicago, Illinois; the Riley monument, Buffalo, New York; Cowan monument, Lewiston; Allen Lombard monument, Augusta; Lyman Nichols' monument, Auburn; Swazey monument, Bucksport; Mitchell monument, Gardiner; Fuller monument, Hallowell, and Meady pedestal and statue, Pittston, Maine; Tenney monument, Methuen, Massachusetts; Washington Artillery monument and Hernandez tomb, New Orleans, Louisiana.

In this quarry there is no sap on the sheets, or at most a very thin film; there are few vertical joints, and the surface of the sheets is smooth and level, while the stone is remarkably free from black patches, those occurring in the quarry becoming smaller in going down. The sheets increase in thickness downward, and are about 1 foot at the top and 10 feet in thickness at 50 feet from the surface. The sheets have a gentle dip to the north. At certain intervals there occur long vertical joints or headings cutting vertically down through the quarry, having an east and west direction, but north and south joints are rare. There are occasional quartz masses in the stone. The rift is horizontal; the grain east and west or parallel to the main seams. Sheets having level surfaces 36 by 34 by 9 feet deep have been loosened, and natural blocks about 200 by 40 by 9 feet deep are found in the quarry. The material is white or rather very light gray muscovite-biotite granite, and is often indistinctly laminated.

At Wayne, Kennebec county, a coarse, massive biotite granite is quarried to a limited extent for cemetery and general building purposes. The market is local only, the stone being used chiefly at Lewiston and Auburn. It was used in the construction of the Free-Will church, Continental mills, and county buildings, Lewiston. The jointing is irregular. Blocks 12 by 12 by 10 feet have been moved, and there are natural blocks about 40 by 15 by 10 feet. It is a safe, free-working stone, and takes a good polish.

Near Canaan, Kennebec county, granite is quarried to a limited extent for underpinnings, and is used chiefly at Waterville, Canaan, and Skowhegan, Maine, and at Newport and vicinity. The underpinnings of the churches in Skowhegan are of this material. The stone lies in very regular sheets from 1 foot to 2 feet in thickness. There is a very convenient rift, but there are many patches. It is a dark gray biotite granite, rather coarse in texture and indistinctly laminated. It is a safe and free-working stone, taking a good polish.

Near Norridgewock, Somerset county, there are quarries producing granite extensively for general building purposes, foundations, and monuments, and to some extent for polished work. Among the buildings in the construction of which the material was used are the following: Stone-work of the Goff block, Auburn; Dunn block, factory, and bank in Waterville; residence of Captain Holland, Lewiston; Coburn hall, Skowhegan; High Street church, Skowhegan; business block in Dexter, and Langley's monument, Lewiston. The principal quarry lies on the top of a hill; the stone is in sheets of from 2 to 4 feet in thickness. The main seams have an east and west direction, and north and south seams are rare. The rift is horizontal. Blocks 30 by 25 by 7 feet have been loosened in the quarry, and natural blocks 150 by 12 by 4 feet can be seen.

At North Jay, Franklin county, granite is quarried for general building purposes and for railroad construction. It has been used in the construction of factories in Lewiston, chiefly for trimmings, and by the Maine Central railroad. It lies in sheets generally quite thin, from 1 foot to 2 feet in thickness, but the excavations thus far are not deep enough to display the jointing very well. The stone is a fine gray muscovite-biotite granite. Blocks 10 by 4 feet by 16 inches have been cut, and blocks 70 by 12 feet by 6 inches have been loosened in the quarry. The stone works well and takes a good polish.

Four miles east of Chesterville, Franklin county, granite is quarried to a very limited extent, chiefly for underpinning, and is used locally. The underpinnings of some of the houses in Farmington are of this stone. It is medium fine-grained, and occasionally porphyritic, indistinctly laminated, lies in very regular, smooth sheets, and varies from 1 foot to 5 feet in thickness; long east and west joints traverse the quarry at intervals; other joints are very rare: the rift is horizontal and remarkably good. There are few patches, but quartz and feldspar veins disfigure the stone to some extent. It is a good working stone, splits readily in the direction of the lamination, and takes a good polish. Blocks 20 by 3 by 4 feet have been moved, and natural blocks about 100 by 35 by 5 feet are found in the quarry.

Three-quarters of a mile east of Bryant's Pond station, on the Grand Trunk railway, in Oxford county, there is a quarry operated by the railroad for its own construction. It was used in the construction of the Bacon Falls bridge near West Paris. The stone lies in rather irregular sheets, generally from 2 to 4 feet in thickness; there are frequent joints having an east and west direction, and dikes parallel to these joints bound the quarry on two sides. The rift is on the lift, the grain vertical and parallel to the jointing. Quartz and feldspar veins are frequent; some patches occur. Blocks 9 by 2 by 2 feet are the largest that have been shipped from this quarry; blocks 60 by 10 by 7 feet have been started by blasting; there are natural blocks in the quarry 75 by 20 by 4 feet. It is a dark gray, indistinctly-laminated biotite granite, is a safe and free-working stone, and takes a good polish.

Three and a half miles south of Farmer, Androscoggin county, there is a quarry producing granite for general building and cemetery work, and used chiefly at Lewiston, Auburn, and vicinity. It was used in the construction of the Lewiston dam, the Episcopal church, Lewiston, and in the Phœnix block, Auburn. The stone lies in sheets of from 1 foot to 6 feet in thickness: the principal joints run northeast, and the grain is parallel to them. The rift is quite good, and is horizontal or in the lift. There are occasional patches in the stone, and white stripes are quite frequent. In producing the material for monumental work these defects cause considerable waste. Blocks 9 by 6 feet by 8 inches have been quarried. It is a dark gray biotite granite, is a good and safe working stone, and takes a good polish.

Two and a half miles south of the dip in Brunswick, Cumberland county, granite is quarried to a limited extent for underpinning and wall work, used at Brunswick, Harpswell, Topsham, and Bath. It was used to some extent in Denison's block, in Brunswick, and in the foundation of Memorial hall, Bowdoin college: Parish church, Portland; Bowdoin College chapel, cotton factory at Brunswick, Exchange building at Bangor, and paper-mill at Topsham.

Memorial hall, Bowdoin college, is quite a large stone structure, with two tall towers, in Norman style of architecture. The stone has stood exposure to the weather very well, but from the use of inferior mortar is greatly disfigured by white efflorescences running down from between the stones. The material itself has a uniform color and the appearance of a quartz in color and splinty cleavage. The mica gives it a glittering appearance, even when seen at a distance. Blocks 40 by 2 feet by 8 inches have been moved, and natural blocks of about 70 by 2 feet by 1 foot are found in the quarry. The stone is a light gray, massive biotite granite, and is a good, safe, free-working stone, taking a good polish.

A few miles south of Pownal Centre granite is quarried for monuments, general building purposes, and street work, and to some extent for columns and polished cemetery work. Paving blocks are sometimes shipped to New York city. The following are some of the buildings in the construction of which the material was used: Gorham normal school; a section of the Lewiston dam; in the lower Lewiston bridge, and the trimmings and foundations of factories there; the stone-work of the Lewiston and the Portland water-works; a portion of the Yarmouth bridge, in Maine, and the larger part of the lower story of the new capitol at Albany, New York.

In one of the quarries the sheets vary from 6 inches to 2 feet in thickness; the rift is on the lift, grain east and west. No sap on the sheets except on the joints, which have an east and west direction, and a dike crosses the quarry parallel to them.

In another quarry the sap is quite thick on the surface of the sheets, remarkably so compared to other quarries in the vicinity, but on the lower sheet it is almost nothing. The sheets are usually less than 5 inches in thickness at the top; the rift is horizontal, the grain has a northeast and southwest direction, the sheets dip east, and great head joints run northeast and southwest through the quarry, though but few of them appear. The stone is quite free from defects. Dikes cross parallel to the headings.

Near Biddeford, York county, granite is quarried for general building purposes and cemetery work, and to some extent for polished columns. It has been used in the construction of sea-walls at Gallup island, point Alton, Long island, and Boston harbor; in the Cross Ledge light-house; the foundation of the new railroad elevator, Jersey City; fine building on Broadway, New York city, in which the material is carved and polished; forts Preble, Scammel, and other forts in Portland harbor, and in numerous breakwaters along the coast; supports of the columns, in part, of the Brooklyn elevated railroad; outside structure of the monument to Abraham Lincoln, Springfield, Illinois; Boone Island light-house, Maine; Whalesback light-house, in Portsmouth harbor, and Cochecho mills, Dover, New Hampshire, and new docks in North river, New York city.

In one of the quarries great seams and occasionally a dike parallel to them traverse it in a northeasterly direction, dipping steeply east, and being perpendicular, with a thickness of 12 feet or less. There are also large joints crossing at right angles in sheets, so that the blocks are irregular in shape. The material contains the usual patches of the Biddeford granite.

In another of the principal quarries frequent northeast and southwest seams traverse it with a steep dip to the east, and run through the quarry from top to bottom, and other, though much less frequent, seams at right angles to these. The stone consequently lies in parallel sheets, dipping steeply, and occasionally so cut by the cross-seams as to be in rhomboidal blocks. The rift is vertical and oblique to both sets of joints. There are black patches.

Adjoining this quarry is another one having very much the same conditions, but there are long, nearly vertical, northeast and southwest seams cutting through the quarry. The rift is oblique to either set of joints. The grain or next easiest splitting direction is horizontal, and the hardest splitting direction is parallel to the main northeast and southwest joints, which is very unusual. There are some horizontal joints also, so that much of the jointing is irregular. In some new openings in the vicinity there are two sets of long joints similar to those described in the preceding, and the stone lies more in horizontal sheets than in the other quarries; these sheets are from 1 foot to 7 feet in thickness. The rift is vertical and oblique to the two sets of joints. The material is a gray biotite granite, is a compact, safe, and free-working stone, and takes a good polish.

Between Kennebunkport and the Boston and Maine railroad, in York county, granite is quarried to a limited extent, chiefly for underpinning, and used at Kennebunkport, Saco, and Biddeford. The stone lies in sheets about 1 feet in thickness and in regular shape; it contains patches and white feldspar streaks. Blocks 15 by 2 feet by 6 inches have been quarried for underpinning. There are natural blocks 75 by 30 by 4 feet. It is a light gray biotite granite, coarse in texture, and massive.

From 7 to 10 miles north and northwest of Kennebunkport there are quarries producing granite for general building purposes, polished columns, monuments, and cemetery work. Among the structures in which the stone was used are the Creshore works at Portsmouth, and the vault of a bank at Exeter, New Hampshire; Newburyport Savings bank and a Catholic church; and the foundation of the Boston Bridge Company's building, Cambridge, Massachusetts.

In one of the principal quarries the stone lies in rather irregular sheets and is irregularly jointed. The sheets vary in size, one being from 9 to 12 feet in thickness. The most prominent joints run southeast, and the rift is parallel to these, though not well defined in any direction. There are occasional patches. In another one of the quarries the sheets are not well marked, and the stone lies between great headings running N. 50° E., and dipping steeply to the westward. The rift is vertical and at right angles to the course of the headings. There are few patches.

In another quarry the stone lies in sheets varying from 5 to 9 feet in thickness. The principal vertical joints run southwest through the quarry at intervals, and there is a dike crossing it parallel to these joints. There are also some large headings at right angles to these. The rift is vertical and parallel to one set of headings. Patches are few. Blocks 18 by 20 feet by 20 inches have been quarried, and there are natural blocks of 50 by 30 by 12 feet. The stone is a gray biotite granite, massive, and coarse in texture.

Four miles southeast of South Berwick, York county, granite is extensively quarried for general building purposes and cemetery work. The following are some of the structures in which it was used: Stratford Company's house, near Dover, New Hampshire; stone-work of the Cunningham shoe factory, and a large tomb in the cemetery at South Berwick, Maine. This quarry has not been sufficiently developed to show the jointing, which at present seems very irregular. The stone is free from patches and the rift is horizontal.

NEW HAMPSHIRE.

(Compiled mainly from notes of Professor C. H. Hitchcock.)

GRANITES.

At Plymouth, Grafton county, a massive, gray biotite granite is quarried for general building purposes, culverts, and monumental work. The culverts of the Boston, Concord, and Montreal railroad are built of the Grafton granite. Natural blocks 20 by 15 by 10 feet are found in the quarry, and the material of the stone lies in horizontal sheets from 2 to 10 feet in thickness.

At Lebanon, Grafton county, the granite, properly a biotite-epidote gneiss, is quarried for general building and cemetery work. The principal markets are Lebanon and Hanover, Vermont. Natural blocks 10 by 10 by 40 feet are found in the quarry. There are obscure signs of stratification, and dips about 70° northwest. All the quarries here show the same features of dip. The workable granite is in horizontal sheets, and the workmen follow the material horizontally into the hill. The joints dip 70° easterly; one or two have a southeast direction. The rift is horizontal. (See *Geological Report of New Hampshire*, Vol. II, p. 355: "Inverted Dip.")

At Hanover, near Enfield village, Grafton county, a gray, massive biotite granite is quarried for general building purposes. The principal market is Hanover, New Hampshire. The stone lies in sheets varying from 6 inches to 9 feet in thickness. It is coarse in texture and not susceptible of a good polish. Natural blocks 200 by 12 by 9 feet are found, and blocks 23 by 9 by 8 feet have been quarried. Discolored joints are found at all depths to which the stone has yet been quarried.

At Rumney, Grafton county, a gray, massive biotite granite is quarried for monumental and building purposes. The stone was used in the construction of the Franklin monument at Plymouth. It lies in horizontal sheets, and the largest natural blocks are 20 by 5 by 5 feet. It is pronounced by Professor Hitchcock to be of the same horizon (Montalban) as the Concord granite.

At Sunapee, Sullivan county, a massive, biotite-muscovite granite is quarried for monumental and building purposes, and is used principally at Newport and Claremont. There are two principal varieties as to color, a light gray and a dark gray. The sheets have a dip of 25° west. Of the two kinds of granite which have been protruded through the porphyritic gneiss at this place black granite is the oldest, which is known from the fact that pieces of it are found in the light-colored granite. This light granite is really the equivalent of what, in Professor Hitchcock's report on New Hampshire, is called the "Upper Bethlehem", but he pronounces it an eruptive granite. Dr. George W. Hawes, in his first catalogue of lithology for New Hampshire, calls this black granite a mica schist. The black granite has the usual appearance of an erupted mass; the ledge of white granite does not reach 100 feet in width, therefore the quarry is limited though well situated. The seam of epidote lies between the two granites. Both varieties are compact, good, and safe stones to work, and take a high polish.

At West Concord, Merrimack county, a massive, gray biotite-muscovite granite is quarried for general building purposes and cemeteries. Among the prominent buildings in which the stone was used are the Horticultural hall, Security bank, the city hall, and Masonic temple, Boston; the Philadelphia city and county building (part), and the Massachusetts state prison, and the *Herald* building, Boston.

At Concord a massive biotite-muscovite granite is quarried for monumental and building purposes. Among the prominent buildings in the construction of which this stone has been used are the Life Insurance Company's building, Boston; monument to the discoverer of anæsthetics, at Public garden, Boston, and the Cadet monument Mount Auburn cemetery, Cambridge, Massachusetts; soldiers' monument, Concord, Massachusetts; Charter Oak Insurance building, Hartford, Connecticut; Jordan & Marsh's building; soldiers' monument at Manchester, New Hampshire; Equitable Life Insurance and Germania Savings Bank buildings, and the city hall and Horticultural hall, Boston, Massachusetts. It is a good, safe, and free stone to work, and takes a high polish. For commercial purposes this granite is divided into four classes: 1st, the best for monumental work; 2d, the next best for general building purposes, where one good face is sufficient; 3d, second quality of stock, including much of the underpinning for ordinary dwelling houses, steps, capping for walls, and hitching posts; 4th, foundation stones, piers, and abutments, and other uses in which uniformity of color is not desired.

Some of the principal quarries are situated on what is known as Rattle Snake hill, which elevation consists almost wholly of a granite formation. The stone on the south side is very light colored; that on the north side is darker. The elevation is 600 feet above the Merrimack river, and the distance from the river to the crest of the hill is 2 miles. The surface of the rock is polished down by glacial action as smooth as an earthen plate. There are some patches of a darker color than the prevailing material, some of which are 18 inches in diameter. Masses of quartz from 1 inch to 6 inches in diameter occasionally occur in the stone. The rift inclines to the west about 1 inch to the foot, and the grain is vertical, having a north and south direction. There are also some joints having a southeast and northwest direction crossing the regular east and west joints. In one of the principal quarries on the east side of the hill the stone fractures best with an east and west line.

Oak hill is a similar elevation to Rattle Snake hill, and is also a granite formation, but the material is usually coarser and more broken. Dikes running through the hill cause variations in the structure of the mass.

A massive, gray biotite-muscovite granite is quarried at Allenstown, Merrimack county, for general building purposes and cemetery work. The natural advantages of this quarry are of the very best, and few of the New

Hampshire quarries are better situated for drainage, size of sheets, availability, and convenience to railroad and markets. It is on the Concord railroad, midway between Concord and Manchester. The material is of medium fine texture, and is jointed horizontally and vertically. There are natural blocks 80 by 20 by 10 feet.

At Durham, Strafford county, a massive, gray biotite granite is quarried for foundations and for flagging. It was used in the foundation of Sawyer's mill, and most of the buildings in Dover, and is transported by boat and wagon. It is coarse in texture, and is a good and safe stone to work, taking a good polish. It lies in sheets of from 6 inches to 2 feet in thickness, inclining to the west. There are natural blocks 20 by 15 by 4 feet in thickness. It lies at the horizon called by Professor Hitchcock "Exeter syenite".

At Raymond, Rockingham county, a pinkish-gray, indistinctly-laminated biotite granite is quarried for general building purposes and cemetery work. The principal markets are the large towns in the neighborhood. The stone was used in the foundations of the custom-house at Portsmouth. The texture is medium fine, and has a jointing similar to the granite quarried at Manchester. Blocks 24 feet square have been quarried. This granite works well and takes a good polish. Professor Hitchcock reports this stone as weak and not likely to be much used save where good stone is scarce, as in the lower part of New Hampshire.

At Peterborough, Hillsborough county, a light gray, laminated muscovite-biotite granite is quarried for general building purposes and curbing. The principal markets are Worcester, Lowell, and Lawrence, Massachusetts. This stone is sometimes called a gneiss from its distinctly-laminated structure; it would perhaps be more proper to term it a gneiss than a granite. It splits readily in the direction of the lamination and takes a good polish. The texture is coarse, and the sheets incline 70° to 75° west. Blocks 28 by 6 by 10 feet have been quarried, and natural blocks 36 by 6 by 12 feet are found in the quarry.

At Milford, Hillsborough county, a gray, indistinctly-laminated biotite granite is quarried for general building purposes and cemetery work. The prominent buildings in the construction of which this stone has been used are the Merchants' exchange, Nashua, and the engine-house at Lowell; the town hall at Wakefield and court-house in Worcester, Massachusetts; and the Wilcox block, at Windsor, Connecticut.

There is quite a number of different quarries in this granite near Milford, and the material is generally a good and safe stone to work, taking a good polish. Blocks of any desired size are found in these quarries, and in many places there are irregular, large, vertical dirt joints, and in some of them coarse sand from 2 inches to 2 feet in thickness separates the sheets.

At Mason, Hillsborough county, a gray, indistinctly-laminated biotite granite is quarried for cemetery and street work and general building purposes. The principal markets are Lowell, Worcester, and Walton, Massachusetts. There is quite a number of very coarse granite veins, varying in thickness from 2 inches to 2 feet, which are called "salt veins" by the quarrymen. The larger blocks of granite are quarried with facility, by reason of the existence of these small veins. The stone is of medium-fine texture, is good and safe to work, and takes a very high polish. In one of the principal quarries the typical two sets of joints cross each other, and are very regular, a fact which is not, however, unusual in the granite of this region. Seams of clay sometimes are infiltrated into the joints. With regard to the joints Professor Hitchcock states that all the New Hampshire quarries have usually the following: 1st, a set of horizontal seams or joints, enabling the workmen to raise the stone parallel to the surface; 2d, vertical joints, usually well pronounced; 3d, scattering joints, often causing the rectangular blocks produced by the first two sets to become wedge-shaped. Sometimes only one of these wedges is worked. Invariably these seams that are highly inclined, if pronounced, carry some dirt derived from muddy water. Many quarries have no scattering joints at all. The line governing their occurrence has not yet been discovered.

Near Nashua, Hillsborough county, a light gray, indistinctly-laminated muscovite granite is quarried for foundation and dimension work. This stone is well adapted to foundations, buildings, and street and cemetery work, where simple rock-faced work is required, but is not adapted to ornamental or fine hammered work. For better classes of building purposes in this vicinity the Nashua granite is used, and the Concord granite for ornamental work. Slabs 20 feet long, for cemetery borders and underpinning, have been obtained from this quarry.

At Wilson hill, 1½ miles from Manchester station, Concord railroad, Hillsborough county, a pinkish gray, indistinctly-laminated biotite granite is quarried for foundations and underpinnings and trimmings for buildings. The principal market is Manchester. It is assigned geologically to the lake gneiss. The texture is coarse, and has the usual horizontal and vertical jointing of New Hampshire granites. It is of value chiefly because within the limits of the considerable city of Manchester.

At Fitzwilliam, Cheshire county, a massive gray granite is quarried for general building purposes, ornamental work, and paving. The principal markets are New England and the west. Among the structures in which this stone has been used are Saint Paul's church, Worcester, and the trimmings of Murdock block, and the national bank, Winchendon, Massachusetts; soldiers' monument at Granville, New York; Keene (New Hampshire) court house; court-house at Albany, New York; trimmings of Morse Institute, Natick; court-house at Fitchburg, and Kraft's block, Pearl street, Boston, Massachusetts. The Fitzwilliam granite is of a fine or medium-fine texture, and varies in its ingredients so that the microscope shows specimens from some quarries to be muscovite-biotite granite; from others, biotite granite; and some of the material is laminated so that it may be termed a gneiss. In one of the principal

quarries there is a light gray muscovite granite and a dark gray biotite granite. The geological horizon is that of the Montalban Archæan rocks. The position of one of these quarries is mentioned as particularly favorable; it is located on the broad north slope of a hill, drains itself, and a very large surface has been exposed to view. If at all defective, it is in the existence of many thin sheets. The Fitzwilliam granites are generally compact, free, and safe-working stones, taking good polish.

One and one-quarter miles east of the depot of Marlborough, Cheshire county, a gray, massive biotite granite is quarried for building and paving purposes. Among the prominent buildings in the construction of which this stone was used are a church and the Union depot, Worcester, Massachusetts; stone mill at Harrisonville, railroad bridge at Keene, and library building in Marlborough, New Hampshire. The stone lies in sheets which are inclined from 2° to 5°, and vary in thickness from 3 inches to 3 feet. There are natural blocks as large as 30 by 14 by 2½ feet. The stone is good and safe to work, and takes the highest polish. Geological horizon, Montalban.

At Troy, Cheshire county, granite is occasionally quarried for local purposes. It was used in the construction of the bank and court-house in Fitchburg. Some of the quarries there produce excellent material for curbing, being hard and brittle, but free from iron.

At Roxbury, Cheshire county, granite is occasionally quarried for local purposes, and it was used to some extent in the construction of the state-house, in Albany, New York, which was in fact the chief purpose for which the quarries were operated.

VERMONT.

[Compiled mainly from notes of Professor C. H. Hitchcock.]

MARBLES AND LIMESTONES.

The noted marble districts of Vermont are in the vicinity of Rutland and Sutherland Falls, Rutland county; Dorset, Bennington county, and on the islands and near the shores of lake Champlain, in Grand Isle and Franklin counties, known generally as Lake Champlain marble. The marble of Rutland and Bennington counties is used very extensively throughout the United States for general building and monumental purposes, and is among the most widely known marbles in the country. According to the classification adopted in this report, this material varies sufficiently in its composition so that some of it may be properly called a limestone, some of it a magnesian limestone, and some calcareous dolomite. Like nearly all the other material known in the markets as marble which is quarried in this country, it belongs to the Lower Silurian formation. The strata of the rock are usually inclined at various angles, and the courses are of such thickness and the jointing is of such a nature that blocks of any desired size may be obtained. In color it varies from white to a dark bluish, and some of the white is of such quality that it is used for statuary purposes.

The Lake Champlain marble from Swanton, Isle La Motte, and other places in this district varies in its composition so that it is sometimes a magnesian limestone and sometimes a dolomite. It is used chiefly for interior work, mantels, tables, inlaid work, and tiling, and may be seen in many of the most important structures in the country. It is of various mottled and variegated colors. Some of the quarries produce black marble. The variegated appearance of some of this marble is heightened by its highly fossiliferous nature.

GRANITES.

Nearly all of the granites quarried in Vermont are of the Calciferous mica-schist, a formation which Hitchcock states may be as late as Devonian, certainly not earlier than Upper Silurian. They are usually biotite granites of various shades of gray, and have not as extensive a use throughout the country generally as the New England granites situated on the coast—a fact probably due to the less expensive means of transportation of the coast granites. The Saint Johnsbury granite, which, according to Winchell, belongs to the lake group of New Hampshire, is quarried extensively, and is marketed chiefly in the neighboring cities of New York.

SLATES.

The important slate formation of Rutland county, Vermont, is, according to Hitchcock, of Cambrian age. The principal quarries are near Northfield, Castleton, Fairhaven, Poultney, and Powlet, and produce material for roofing, mantels, billiard tables, tiles, school slates, trays, sinks, furniture, and for ornamental and various other purposes. The different colored slates obtained are chiefly a bluish black, purple, and green. They are used throughout the United States for the purposes before mentioned.

CONNECTICUT.

[Compiled mainly from notes by Harrison W. Lindsley.]

BROWN AND RED SANDSTONE, TRIASSIC FORMATION.

The surface rocks of Connecticut are Archæan rocks, covering most of the area of the state; a small Lower Silurian area, chiefly in the northwest corner of the state, producing limestones which thus far have been quarried only to a limited extent for purposes of construction; and the Triassic rocks of the Connecticut valley, extending,

according to Professor J. D. Dana, from New Haven, on Long Island sound, to northern Massachusetts, having a length of 110 miles and an average width of 20 miles. This formation furnishes the celebrated brown sandstone quarried at Portland and at other places in the Connecticut valley. The principal quarries are at Portland and at Middletown, on the east bank of the Connecticut river, near the junction of the Air-Line and the Connecticut Valley railroads, in Middlesex county. These quarries are operated on a very extensive scale, and the most improved methods of quarrying are in use, the work being largely done with steam channeling-machines, as the stone is of such a nature that it is readily cut in this way.

The "Connecticut brownstone", as it is known in the market, is extensively used for all kinds of building and monumental work in the principal cities of the Atlantic border, in Canada, and in Chicago. Most of the fronts on Fifth and Madison avenues, New York city, are built of this stone. Transportation is by boat and by rail. The wharves are situated within 100 yards of the quarries, and railroad tracks are extended into the quarries. The material is very uniform in character and appearance. A considerable quantity of stone from each of the quarries was used in the construction of the Vanderbilt brownstone house on Fifth avenue, New York, and was used indiscriminately in the front of the building. Blocks about 30 by 7 by 7 feet have been moved in the quarry, and there are natural blocks as large as 100 by 50 by 20 feet, so that blocks of any desired size may be obtained. This stone splits in uniform layers from one-sixteenth of an inch in thickness to 15 or 20 feet thick. The texture is medium as to fineness of grain compared with other sandstones, and is very uniform. According to Dana this sandstone is largely a granitic sand-rock made of pulverized granite or gneiss. The following analysis of a specimen was obtained by Mr. F. W. Taylor, chemist of the National Museum:

	Per cent.
Silica	69.94
Iron sesquioxide	2.48
Alumina	13.55
Lime	3.49
Magnesia	trace
Soda	5.43
Potash	3.30
Ignis iron	1.01
Manganic oxide	0.70
	99.50

The Connecticut brownstone should invariably be laid in walls as it lay in the quarry bed, as the signs of stratification are usually distinct, and the material has a tendency to split when set on edge.

There are also extensive brownstone quarries at East Haven, near New Haven, on the Air-Line railroad. The stone at these quarries differs in some respects from that quarried at Portland; it is here a reddish, rather coarse stone, containing much quartz in grains, and is employed chiefly for foundations, underpinnings, and railroad work at New Haven, and by the railroad companies of Connecticut and Massachusetts. It was used in the construction of Saint Paul's church, New Haven, and for the abutments and piers of numerous railroad bridges. The stone is in quite uniform layers 2 or 3 feet in thickness, and blocks 20 by 4 by 3 feet have been obtained. The joints are not frequent and are quite irregular.

Small quarries of the Triassic sandstone are operated at several other points chiefly for local use. Among these points may be mentioned Buckland station, Hartford county, on the Hartford, Providence, and Fishkill railroad, where stone of a very beautiful reddish color, but slightly coarser grained than the Portland stone, is obtained. The material here seems to be in every way suitable to all general building purposes, and can be obtained in blocks of any size ordinarily required. The quarry has also good facilities for transportation by rail.

At Hayden's station, within a few yards of the New York, New Haven, and Hartford railroad, is a quarry of brown sandstone formerly operated to supply stone for the dam at Windsor ferry. It has been operated for local uses for a hundred years. The stone is similar to the Portland stone, but somewhat redder in color, and as there are good facilities for transportation, both by railroad and river, it may be of importance in the future.

At Suffield, Hartford county, there are a number of small brownstone quarries, none of which have been operated except for local or private purposes. Other quarries are operated for local purposes at Newington, Hartford county, Farmington, and Forestville. It will be noticed, however, that the extensive quarrying in Connecticut on this formation is done only at Portland and East Haven.

The principal quarries on the trap dikes of the Triassic age in Connecticut are at East rock and West rock, north of New Haven. The material here is diabase, nearly black in color, fine and uniform in texture, and it is used for cellar stone and street paving in New Haven. This rock is much cut by irregular joints, so that blocks of a size suitable only for cellar work and paving stone can be obtained; however, it serves well for these purposes.

GRANITE AND SYENITE.

Extensive quarries of granite and gneiss are located at various points in the state, especially near Thomaston and Roxbury, in Richfield county; on Long Island sound, in Fairfield county; near Ansonia, Branford, and Stony creek, New Haven county; Middletown and Haddam, Middlesex county; and near Lyme, Niantic, Groton, and Mason's

island, New London county. The Connecticut granites and gneisses are usually fine grained and light gray in color, and the appearance is usually so characteristic as to distinguish them from other granites of the Atlantic Coast states.

At Sterling, Windham county, a biotite gneiss, rather coarse in texture, and varying in color from gray to light gray with a pinkish tint, is extensively quarried for general building purposes, monuments, and street work, and is shipped chiefly to Willimantic, Jewett City, Danielsonville, and Baltic, Connecticut, and to Providence and Warwick, Rhode Island. Among the structures in which it has been used are the Furnace block in Willimantic, the Baltic mill, and mills at Warwick, Rhode Island.

Near Thomaston, on the Naugatuck railroad, a light gray biotite-muscovite granite is quarried extensively for general building purposes, and shipped to Waterbury and the towns in the western part of Connecticut generally. Among the buildings in which it was used are the United States building (front), New Haven, and the Episcopal church, Waterbury. The material in the quarry lies in quite irregular sheets, usually inclined about 20°, and has a slightly gneissoid or laminated structure.

At Roxbury, the granite quarried for curbs, foundations, and paving, and employed chiefly in Danbury, Connecticut, and New York city, is similar in structure and composition to the Thomaston granite.

The quarries on the shore of Long Island sound produce a hornblende-biotite gneiss, used extensively for foundations, underpinnings, footings, and piers in New York city and Brooklyn. Transportation is by schooner on Long Island sound. The color of this material is a very dark gray, approaching black.

Near Ansonia a blush-gray muscovite-biotite gneiss is quarried for general building purposes and used in the vicinity, at New Haven and Bridgeport. Among the structures in which it was used are the copper-mill and clock shops in Ansonia, and Howard Avenue church, New Haven. This gneiss splits very evenly in slabs of almost any thickness. Slabs of 4 inches in thickness can be obtained about 2 feet in width and from 4 to 6 feet long. The rock on the natural surface looks fibrous like a piece of straight-grained wood, and splits vertically in the direction of this grain as well as in the plane of the quarry bed. It can be successfully polished only at right angles to the plane of lamination. A large seam of quartz about 6 feet square in the section crosses on top of this quarry in almost a straight line, having a direction northeast and southwest. This rock is exposed at many points in the vicinity, and probably could be profitably worked at nearly all of the outcrops.

Near Branford the material, though locally called granite, is a biotite gneiss, and has thus far been used for breakwaters and coast engineering works at fort Jefferson and New Haven. A portion of the breakwater in New Haven harbor was constructed of this material. It is shipped in barges. This stone is not very uniform in texture and color; even in the same quarry it varies in color from dark gray to a pink.

A biotite granite is quite extensively quarried at Leetes Island station, 6 miles east of Branford, on the Shore Line railroad, in New Haven county. It is used for general and ornamental purposes, chiefly in New York city. Among the structures in which it has been used are the bridges at Springfield and Harlem. It is transported by boats.

The stone quarried at Arnold's station and Maromas station, on the Connecticut Valley railroad, in Middlesex county, is a very dark gray or black hornblende-biotite gneiss, varying from fine to coarse in texture, and used chiefly for curbs, flagging, and steps and street work at Philadelphia, Pennsylvania, Camden, New Jersey, and Springfield, Massachusetts. It is transported by schooners and boats. This rock is considerably marked with fine white veins from one-eighth of an inch to 2 inches wide running irregularly through it. There are occasional quite large veins of quartz, much stained with iron, running through the ledge, but the iron stains are only on the surface. This stone was called blue-stone in the market before the North River blue-stone was extensively used. There is a streak running through portions of the ledge of very much finer and darker colored stone, which splits with a smooth, almost black surface, due to the black-mica scales. Nearly all the mica in this rock is black, and to this fact is due the very dark color of the material.

Material of a similar nature has been quarried at Deep river, at Saybrook, Hadlyme, and Haddam, on the east bank of the Connecticut. In the principal quarries the cleavage is nearly vertical and at right angles to the beds, thus making it easy to obtain blocks of required shape.

At Maromas station the quarry rock is without any jointing or division into sheets, being a solid mass, excepting near the surface. It splits, however, very easily in horizontal planes in any thickness, is very uniform in appearance throughout, and very easily quarried. The quarry is at such a level that it can be drained by the siphon. It is close to the Connecticut river and the Connecticut Valley railway, so that the facilities for transportation are good.

The quarries near Lyme, Niantic, Groton, and Mason's island produce chiefly a gray biotite granite. There is, however, one quarry near Lyme producing a red granite, locally called "red porphyry". The texture is coarse and porphyritic; it is used for general building and ornamental purposes, chiefly at Newport, Rhode Island. Some of the material may be seen in the Chaney Memorial church, Newport, Rhode Island.

The other principal quarry near Lyme produces a plain gray granite, rather coarse in texture, and shows on all dressed surfaces fine parallel lines of alternate dark and gray. These lines prevent its use for the most highly ornamental purposes, as they usually run obliquely across some or all of the finished surfaces. Portions of the material in this quarry are slightly pinkish in color.

The Niantic quarries produce a light gray granite of rather fine and uniform grain, used for general building purposes, monuments, and paving, chiefly in New York city, though it is used in various places in Connecticut and Rhode Island, and has been shipped as far south as Savannah. It is transported by boats. Among the structures in which it has been used are the Norwich court-house, the New York reservoir, and fort Adams, Newport, Rhode Island. The surface rock of this and other granite quarries in the southeastern part of the state is thought to be looser in texture than the rock below and much more easily broken. It is often coarser and less uniform in texture. The usual thickness of this surface rock is from 5 to 15 feet. It is utilized for riprap and similar rough purposes, and may be considered as the lowest grade of the production of these quarries. At the Niantic quarries there are two grades, the finest grain being a perfectly uniform gray in color on a polished surface, and the second having a polished surface covered with spots from one-half to three-quarters of an inch in diameter, quite uniformly spaced from 1 inch to 3 inches apart, and looking much as if a wet finger had been repeatedly applied to the smooth surface. The discoloration in natural joints does not penetrate the stone at all, but discolors the whole surface of the joints as far as it extends.

These quarries are the largest located on Long Island shore between New Haven and the Rhode Island line. They have supplied material for a large number of the ports along the Atlantic coast and for government works at many other places. A small portion of the material at certain sections in the quarries is slightly pinkish in color.

The granite quarried at Groton is a light gray material of a rather fine and uniform grain. It is used for cemetery work, monuments, curbs, trimmings, and breakwaters, chiefly at Providence, New Haven, Hartford, Buffalo, Erie, Milwaukee, Cincinnati, and Chicago. The transportation is partly by boat, but chiefly by rail. Nearly all of the material of the best quality produced by these quarries is used for ornamental work, as it is uniform in color and texture and takes a fine polish. Much of the stone shipped from these quarries is dressed and finished.

At Mason's island, south of the Mystic river, Long Island sound, a gray granite is extensively quarried for riprap and breakwaters. The ledge is very much broken by joints, and blocks of large size are not readily obtained, though the quality and structure of the material and the location of the quarries make it well adapted and convenient for the purposes for which it is used. The material thus far quarried has been chiefly the surface rock. At several places, however, large sheets of what seemed to be much more uniform and better granite have been reached. The rough rock overlying these sheets is from 15 to 30 feet thick.

At Mystic River there is a granite quarry producing a fine quality of gray granite, which may be obtained in blocks of any desired size. As yet, however, it has not been much operated. This quarry is situated on the side of a steep cliff or ledge, very accessible and conveniently located for quarrying, near the Mystic river.

At North Bridgeport, Fairfield county, and Killingly, Windham county, gray and rather coarse-textured hornblende-biotite gneiss is quarried for local use. A material of similar character is quarried at Willimantic for curbing and flagging, chiefly for local use. Fine-grained gray-biotite gneiss is quarried at Bolton, Tolland county, for flagging, and used chiefly in Hartford; it is, however, shipped to some extent to other New England cities.

Dark gray biotite gneiss is quarried for street work at Glastonbury, Hartford county, and used chiefly in Hartford.

At West Norfolk, Litchfield county, a very beautiful light gray, fine-grained gneiss is quarried. It is uniform in texture and color, and has a bright, fresh appearance. It is nearly all distinctly laminated, and is a biotite-muscovite gneiss, though specimens forwarded to the National Museum are properly called "granites".

SERPENTINE AND VERD-ANTIQUE MARBLE.

In the Archæan rocks near New Haven are deposits of serpentine and verd-antique marble, which have not thus far been quarried to any great extent, although if worked they would furnish excellent material for interior decoration and other ornamental purposes.

The serpentine is gray, mottled, yellowish, and greenish in color when rough; when polished it is dove-colored, with lines of yellow and green.

The verd-antique marble is of a grayish color when rough; when polished it is dove-colored, yellow, greenish-yellow, and black and white. The difficulty of dressing and polishing this material seems to have prevented its extensive use thus far.

NEW YORK.

[Compiled mainly from notes by Professors Cook and Smock.]

GRANITE.

Granitic rocks are quarried for local use in a number of localities in Westchester county, and the material is generally fit for rough work only. The gneiss quarried near Hastings by Messrs. Munson & Co., however, is used principally in New York city for foundations and general construction purposes. This is a rather coarse grained material, and is striped by alternate layers of light and dark, varying in thickness. Nearly all varieties, as to color, texture, and composition, occur in this region, though no very valuable exposures have been developed in localities convenient to water transportation.

In Putnam county the granitic rocks are well developed, and have been worked in various localities in cliffs along the Hudson river.

On Grindstone island, one of the Thousand islands, Jefferson county, a beautiful red granite is obtained, which is rather hard to dress, but is susceptible of being very highly polished.

The product of the quarry is at present manufactured into paving blocks and stones for monumental work; the former are used in Chicago, Illinois, and the latter are shipped to Montreal. The quarry is favorably located for transportation by the great lakes and the Saint Lawrence River system of navigation; it is on the west side of Grindstone island, about 5 miles west of Clayton, Jefferson county, and at the dock adjoining the quarry vessels of 400 tons burden can land.

SANDSTONE.

At Malone, Franklin county, the Potsdam sandstone is crossed by the Salmon river, and here some stone is quarried for local demands, but no quarries were reported as worked during the census year.

Three miles south of Potsdam, Saint Lawrence county, the Raquette river cuts across the Potsdam formation, and quarries are worked along the banks of this stream. The outcrop of the sandstone where it is cut across by the river is about 2 miles in width from north to south. The strata dip in a southerly direction at an angle of 45°. The formation shows signs of disturbance, and the layers near the surface are thin and are used for flagging. As the excavation proceeds downward the layers gradually increase in thickness until, in the bottom of the quarry, at a depth of about 40 feet, the layers are from 2 to 3 feet thick. These layers split readily, when first quarried, into any desired thickness. The stone works well when first taken out, but becomes quite hard upon exposure. Much of this stone has a pleasant reddish-brown color, which is very durable, but some of it shows a rusty discoloration upon long exposure. It is quite refractory, and is used for lining cupolas in the furnaces at Potsdam. A large amount of it has been shipped to New York for use in the construction of the new buildings of Columbia college; three churches, the Normal School building, and the town hall at Potsdam, are also built of this stone. The most westerly point where the Potsdam sandstone is worked is at Hammond, in the extreme western part of Saint Lawrence county. The strata here are very nearly horizontal, but the jointing is irregular. The stone is of good quality, and varies in color from gray to red. Thin layers also occur at the top at this point, and heavy layers are found lower. The quarry is conveniently located for transportation, and the stone is used for curbs, flagging, and paving, principally in towns of central New York.

In Washington county the Potsdam sandstone is from 50 to 60 feet thick, generally covered by alluvium, and nowhere extensively quarried. At Fort Ann it is almost pure quartz, and is quarried for use in the steel-works at Troy, and also for the construction of hearths. There are some small calciferous-sandstone quarries in the vicinity of Fort Ann, which furnish excellent paving stone and stone for underpinnings for local use.

In Schenectady county, at a point called Aqueduct, a valuable development of a sandstone stratum in the Hudson River group occurs. It is a very fine-grained, stratified sandstone, in layers separated by thin seams of slate, and the sandstone grades almost imperceptibly into slate. The strata dip slightly to the southwest, and a system of parallel joints, called side seams, runs nearly northeast and southwest, and is cut across at right angles by cross joints. There are main side seams from 30 to 55 feet apart, very regular and filled with mud, and between these there are irregular parallel joints at distances of from 2 to 12 feet apart. In the southward extension of the formation the strata of slate run out and several sandstone layers unite and thus furnish large-sized blocks. The quarry is located on the bank of the Erie canal, by which the stone is transported to market, and the quarrying is done during the season of canal navigation. The stone works well and is used quite largely for buildings in surrounding cities.

BLUE-STONE DISTRICT.

The "flagging" or "blue stone" of the Hudson River district belongs to several geological formations from the Hamilton upward. The district is confined to comparatively narrow limits west of the Hudson river, and mainly to Albany, Greene, and Ulster counties. It begins with the quarries in Schoharie county, passes to the southeast and enters Albany county near Berne, and from there passes around to the south and southwest, across Greene, Ulster, and Sullivan counties and across the west end of Orange county, to the Delaware river and into Pike county, Pennsylvania. There are no quarries known in any of the formations below the Hamilton down to the Hudson River slate, and the typical blue-stone flagging may all be said to come from the Hamilton formation, which, according to Professor Hall, is succeeded by the Oneonta sandstone, the equivalent of the Portage in the eastern part of the state. The Chemung shales and sandstones have not been identified, and the gray and the red beds of the Catskill mountains probably belong to the Catskill group. It may yet be found that the main blue-stone belt, which extends southwest through Hurley, Ulster county, belongs in part to the Hamilton, while the upper or western beds are of the Oneonta formation. The flat plateau or terrace to the east and southeast may be occupied by the softer Chemung rocks. If this be the case, the quarries of West Saugerties, High Woods, Shandaken, Phœnicia, Boiceville, and Brodhead are all in the Catskill group. The stone from these localities is generally coarser grained than that from the more eastern range, and the gray or the reddish tints predominate over the dark blue-black shades.

The quarry at Eminence, Schoharie county, is probably in the Chemung group. The quarries which are probably in the Hamilton group are the Middleburgh quarry, Schoharie county, the Albany County quarries, those of Greene county and of Quarryville, Saugerties, Kingston, and West Hurley, Ulster county, and those in the southwestern extension of the blue-stone district near Ellenville, Ulster county, and at Pond Eddy and West Brookville, Sullivan county. There is a great number of quarries in this district, and many of them are very small, as little capital is needed to develop a quarry, on account of the small amount of cap rock to be removed and the little machinery necessary to operate the quarries, as they are worked almost exclusively for flag-stones of small size and small "edge stuff".

In Schoharie county the character of the flag-stone is much the same as in the quarries along the Hudson river. There are in the blue-stone formation always two systems of joints crossing each other nearly at right angles. Those of the principal system, which usually runs nearly north and south, are called "main side joints", and the others "cross joints". In the Eminence quarry the main joints run nearly north and south, and the strata dip slightly to the south or southwest. Several ledges are quarried here at different elevations, and the stone varies in texture, the highest strata being coarse-grained and varying in color from gray to red, and the lower layers are blue black and fine-grained. The product of these quarries is principally flag-stone, which is used to supply the local demands of surrounding towns. The quarries of the Middleburgh Blue Stone Company are about a dozen small openings near Hunter's Land, and from 5 to 10 miles east and southeast of Middleburgh. The quarries are nearly all in side hills and the strata are very nearly horizontal. Near the surface a hard, thinly-bedded stone is found, which is suitable for common flagging, cross-walks, and rough work. The quality of the stone is found to improve as the quarries are worked to greater depth, heavier beds of finer-grained and more valuable stone being found. This is a newly-developed blue-stone district, and some of the best stone is suitable for trimmings. The material goes principally to Albany, Troy, and other cities to the northeast.

The stone from the Albany County quarries is coarser, harder, and more gray in color than that from the same formation in Greene and Ulster counties. The Reidsville quarries have an average thickness of workable strata of only 4 feet, covered with from 2 to 14 feet of earth and slaty beds. The quarries in the vicinity of Dormansville were formerly worked quite extensively, but for several years past they have been worked but little. The beds in these quarries are thin, and the stone goes principally to Albany for flag-stone. At Stephensville, 6 miles west of Coeymans, a more easterly range of flagging stone occurs, which, however, has not yet been developed.

The blue-stone belt, extending south from Albany into Greene county, crosses New Baltimore and Coxsackie townships, in each of which quarries have been opened, though very little stone has been taken out. At New Baltimore stone is quarried for dock filling at Albany.

The Leeds quarries consist of six or seven different openings, which are worked at intervals by farmers. The product of the quarries, most of which is for small flags, is carted to Catskill, a distance of about 2 miles. The Kiskatom quarries have been worked, but not continuously, for many years. The blue-stone belt is here quite narrow, and in the ledge worked approaches near to the limestone formations that lie between it and the Hudson. The structure of the beds is similar to that of the same formation farther south. The shipping points for these quarries are Catskill, Malden, and Smith's Landing, from 7 to 8 miles distant. The cost of carting the stone amounts to about 25 per cent. of the value at these points. The stones produced are mostly of small size, and are worked into curbs, caps, sills, steps, etc., called "edge stuff". At Palenville a large number of quarries was formerly worked, extending over a large space, but the decline in prices has put a stop to many of them. The quarries are all at the base of the mountains and several hundred feet above the surrounding lowlands, and a good quality of stone and large-sized blocks may be obtained. The strata dip westward into the mountains, and the thickness of cap-rock increases rapidly in that direction. The distance of these quarries from Malden, the shipping point, is 9 miles.

Ulster county has by far the largest number of quarries in the blue-stone district. Quarryville, in the northwestern part of Saugerties township, is a noted quarry district, which has been worked for 40 or more years, and a large amount of stone has been taken from it. The stone is sold at Malden, and is drawn there over a tramway constructed of blocks of stone. There is much less stone quarried here at present than was formerly produced, as the depth of stripping has increased to such an extent that the quarries can be worked with but little profit. The stone is of good quality and is used for turned and general dressed work at the Malden yards. The quarries lie in lines along three parallel ledges which have a general direction from northeast to southwest. There the blue-stone belt makes its nearest approach to the Hudson, the limestone belt, 3½ miles in width, separating the most easterly ledge from the river. The beds of sandstone overlie each other from west to east, and strata of slate and hard sandstone occur between them. The vertical side seams are very regular and run north 40° east, and the joints at right angles to these are irregular and not continuous. The quarries in the easternmost ledge extend about a mile in length, 175 feet in width, and have been worked to an average depth of about 12 feet. A large area has been left on account of the heavy stripping required.

The line of quarries in the middle ledge extends over an area about 1½ miles in length, from 150 to 500 feet in width, and has been quarried to a depth of from 12 to 20 feet. Quite heavy beds occur in some of these quarries, and the joints often allow blocks of very large size to be obtained. In the western ledge the quarries are in a line about

1,000 feet long by 150 wide, and are worked to an average depth of about 12 feet. These quarries are about 5 miles from Malden, being the most distant of all quarries here noted. The total thickness of workable layers in the Quarryville region is from 4 to 20 feet, and the stripping is from 6 to 17 feet in depth. Much of the heavy or thickly bedded stone is taken to Malden to be worked into edge stuff. In working these quarries little capital is used beyond the value of the necessary tools. Leaseholds are common, and the royalty paid is at the rate of one-half cent per square foot of stone quarried. The larger sizes of blocks have bed dimensions of about 15 by 8 feet, although some 25 by 15 feet have been taken out. The quarries near Saugerties extend in a line from northeast to southwest, about 2 miles in length and half a mile in breadth, and are known as the Fish Creek quarries. A large area has been quarried over and a large amount of stone has been taken out. The quarries have been in operation from thirty five to forty years, but the product is now small and is carted to Saugerties, which is from 4 to 5 miles distant, and the cost of carting amounts to one-third of the value of the stone at that place. The quarries now worked are in the midst of the old works, many of them previously abandoned. They are now not very productive, and a considerable amount of stripping is necessary. The quarry bed is from 3½ to 8 feet thick, and the stripping or cap-rock from 3½ to 7 feet thick. The stone is fine grained and is used mainly for edge stone. The Kingston quarries are all in the same belt, and may be separated into several groups, as the Dutch Settlement group, the Hallihan's Hill group, the Sawkill group, the Jockey Hill group, and the Dutch Hill group.

In the Dutch Settlement group the quarry beds have an aggregate thickness of from 5 to 12 feet, and the strata vary from 5 to 16 inches. Generally two or three men work together in a quarry, and some of the quarries are contiguous and admit of a common system of drainage. The amount of capital invested in this region is very small, as the quarrymen do not often own the land on which they quarry, but pay a rent, usually at the rate of half a cent per square foot for the stone taken out. Formerly a large amount of quarrying was done in this locality, but the increasing expense of working the quarries and the low prices for stone have reduced the extent of the industry. The work is now mainly done by men who have their own boys to assist them, and very few men are hired. In some portions of this region the dip of the strata is to the northwest, and in others to the southwest. From the quarries of the Dutch settlement the product is carted to Glasco, Ulster county, a distance of about 6 miles, and is there sold to dealers for flagging and edge stone.

The Hallihan's Hill series of quarries is on the same ledge as the bed of stone extending southwest from the Dutch settlement to the Sawkill creek for a distance of over 2 miles. At the southern end the ledge is quite elevated, but dips to the northwest and descends until it is lost. It is the extreme eastern one of the blue-stone belt, and immediately to the east of it the land descends to the low district extending to the Hudson. The bed worked in this ledge varies in thickness from 4 to 12 feet, and the cap-rock to be removed is from 4 to 30 feet in depth. The entire length of the ledge has been quarried over. The quarries now worked were opened, abandoned, and then reopened; most of them were left on account of the depth of stripping necessary when prices declined several years ago, and are worked now by the men who were unable to leave with their families when wages were low.

The Jockey Hill and Dutch Hill line of quarries is southwest of the Hallihan's Hill quarries and forms one continuous opening, and nearly the whole surface of the ledge has been quarried over. The strata are from 2 to 3 feet thick, and the quarry beds are separated by strata of hard blue-stone which breaks and splits irregularly. The joints are vertical, and the north and south system is very regular and continuous; the east and west system is less regular and not continuous. Excepting for its quarry stone this district is almost valueless; its surface is very uneven and broken, and covered with forest trees. The stone from this district, as well as from the Hallihan's Hill quarries, is carted to Wilbur, a distance of from 7 to 9 miles. The bed dimensions of the largest blocks obtained from these quarries are 20 by 15 feet, but the possible dimensions of blocks from the quarries are claimed to be 60 by 18 feet. Each quarry has from two to ten quarrymen, very few of whom are employed for wages.

The Stony Hollow group is near the Ulster and Delaware railroad, and is the last group on the belt passing from northeast to southwest through Kingston township. The quarries are small, and some of them are on old abandoned sites. The product is taken to Wilbur on wagons, a distance of 6 or 7 miles.

The quarries of Hurley township are in four principal groups. The Bristol Hill quarries are west of Stony Hollow on the southwest extension of the Stony Hollow line, on both sides of the Ulster and Delaware railroad, but the stone is taken by wagons to Wilbur, a distance of 7 or 8 miles. A large space has been quarried over in the thirty or more years in which the quarries have been worked, and the quarries are at present doing quite an extensive business. An excellent quality of stone, applicable to the finest kinds of work for which the North River blue-stone is used, is obtained here. The West Hurley quarries proper are northwest of Bristol hill, in a noted quarry center, where blue-stone has been taken out for forty years. The area worked over is large. The stone found here is remarkable for its evenness of stratification and regularity of jointing. The joint systems are at right angles to each other, the one running northwest being open and continuous, but the one to the northeast is less regular and interrupted in places. Some of the largest quarries of the blue stone district are in this region. There is generally a lack of capital, and therefore a loss in efficient working. These quarries are on the line of the Ulster and Delaware railroad, but the rates of transportation by railway are so high that the stone is drawn on wagons a distance of 9 miles to the canal at Wilbur.

The Morgan Hill quarries are on the line running southwest from Stony hollow and Bristol hill. They are six in number, all of them quite small, and others in the same range have been abandoned. The locality known as Steenykill marks the southwestern limit of the main Hudson River blue-stone belt, which exhibits the same characteristic features throughout from Quarryville to the Esopus creek, in Marbletown township. Some small openings have been made in the formation just southwest of this creek.

The quarries to the northwest of this belt are, as already stated, in a higher formation. The West Saugerties range of quarries is west of Quarryville and near the foot of the Catskill mountains. Its structure resembles that of the Quarryville ranges, except that the layers are usually thicker. The principal joint system runs north 40° east, and the strata dip slightly toward the southwest. The overlying beds are shale and slate with interstratified beds of rough stone unfit for flagging or edge stuff. The West Saugerties stone has a medium grain and the characteristic color of the North River blue-stone. All the stone is carted to Malden, 8 miles distant, and here the heavier stone is manufactured for various architectural uses. It is quite soft and works easier than much of the North River blue-stone. In the Highwoods quarries the aggregate thickness of the quarry beds is from 4 to 10 feet, and the stripping varies from 4 to 23 feet. Heavy stones are also obtained here, and are cut into sills, caps, and other edge stuff at the yards at Saugerties, 8 miles from the quarries, and at Glasco, from 4 to 6 miles away. At one quarry the layers are from 20 inches to 3 feet in thickness, and a block now exposed is 220 feet long, 26 feet wide, and 1 foot thick. Blocks 25 by 15 feet by 1 foot have been taken from this quarry.

The quarries in the vicinity of Woodstock are on the southern foot of the Catskill mountains, and 1,000 feet above the Hudson river. The strata dip to the northwest, and in some of the quarries the bedding and jointing are somewhat irregular. The layers are usually from 2 to 10 feet thick; the aggregate thickness of the beds is about 20 feet; the stripping is mainly slate, and usually heavy. The product is carted to Saugerties, 11 miles distant, except from the quarries of Messrs. Elting & Maxwell and P. H. Lapo; these two quarries are northwest of Woodstock; the latter is farthest in the mountains, 1 mile northwest of Cooper's lake, and several hundred feet above it. The product of these quarries is carted to Malden, from 16 to 17 miles distant, and is used almost exclusively for cut work.

The Shandaken quarries are in a locality known as Fox hollow, a short distance from the Ulster and Delaware railroad, by which the product is shipped to Rondout, and thence by river to New York city. This stone has a gray color; the layers are from 10 to 12 inches in thickness, and large-sized blocks are easily obtained, but the material is not so much desired on account of its color as the typical blue-stone. There are only two quarries as yet opened on Woodland creek, and it is quite probable that the entire eastern bank, for a considerable distance, is bordered with ledges of sandstone suitable for building and flagging. The rock is of good quality and works freely. Two distinct grades are obtained; the upper part of the bed worked is of a reddish color and rather coarser in texture than the lower portion, which is grayish in color. The bed dips toward the valley, and as it is worked back into the mountain it rises so that the stripping does not increase rapidly. The bed has been worked to a depth of 18 feet and the bottom is not yet reached. The layers are from 2 to 12 inches in thickness, and increase in thickness with the depth of the quarry. Many of the quarries in the vicinity of Phœnicia have been opened quite recently. The amount of stripping in the Phœnicia quarries is about 20 feet, making the working of the quarries rather expensive, but the excellence of the stone and the large and heavy blocks to be obtained make the quarries profitable. The Ulster and Delaware railroad also furnishes cheap transportation.

The quarries near Brodhead are all west of Esopus creek, and from 2½ to 4 miles from the station. Nearly all the stone from these quarries is dressed at Brodhead, and thence shipped to market over the Ulster and Delaware railroad. This stone is of good quality, but there is a lack of capital to open workable beds. The aggregate thickness of the beds is from 4 to 11 feet, and the stripping from 4 to 14 feet, and in some places increasing rapidly.

As has been indicated, the blue-stone formation is traceable to the southwest from the Hudson River quarries through Rochester and Wawarsing, Ulster county; and occurs in Neversink, Fallsburgh, Mamakating, Thompson, Forestburgh, Lumberland, and Highland townships, Sullivan county; and in Deer Park township, Orange county. The Rochester and Wawarsing quarries are all small openings, and generally worked on leases, along the valleys of Vernoog, Beerkill, and Lackanack creeks, all tributaries to Rondout creek. At the quarries on Vernoog creek the beds dip at an angle of 20° to the north, 60° west, and the average inclination of the strata in this region is 20°. The stone is coarser grained in these quarries than in those nearer the Hudson, but is thought to be equally strong and durable. There are many abandoned openings in this region. All these quarries are small, and the workable beds are soon exhausted on account of the steep inclination of the strata. The quarries along Beerkill creek are not now in operation; they were worked quite vigorously for a time to supply Ellenville with stone for sidewalks—a town of about 4,000 inhabitants, which has 14 miles of stone sidewalk.

Along the Delaware river the flagging-stone belt is exposed from near Pond Eddy up the stream nearly 25 miles to Lackawaxen, Pike county, Pennsylvania. The principal quarries on the New York side are in the vicinity of Pond Eddy. From one of these two large flags were furnished, each 25½ by 15½ feet by 7 inches, and their width was limited only by the size of the boats which could go through the locks of the Delaware and Hudson canal.

These quarries on the Delaware river are noted for their excellent quality of stone. The strata are here again nearly horizontal, and from 1 inch to 1 foot in thickness, and the maximum amount of stripping is 10 feet. The product is mainly taken by canal to New York city.

The quarries along the valley from West Brookville, and those along the line of the Monticello railroad, in Mamakating and Forestburgh townships, Sullivan county, are usually small. Their total production has declined greatly within ten years. The West Brookville quarries are on the mountain side, several hundred feet above the canal level, and all the stone is carted to the canal at West Brookville. Some of this stone has a reddish color, and is said to be stronger than the Ulster County stone; but the market prices are higher for blue-stone, and there is a prejudice against red or gray shades of color. Along the Monticello branch of the Lake Erie and Western railroad there are numbers of small quarries, all of which open into steep side hills, and have a rapidly-increasing amount of stripping.

There is a great number of small openings in this region which have been abandoned. The amount of stripping is always considerable, and the aggregate thickness of the quarry beds is small and the layers are thin. The stone has the color of the Hudson River stone, but it is very hard, and none of it is equal in quality to that obtained in the Hudson River quarries. A new flagging-stone district has been made accessible to the markets by the New York, Ontario, and Western railroad, running across Sullivan and Delaware counties, and stone is being shipped both eastward and westward. The business was insignificant during the census year.

In Delaware county the flagging-stone quarries are along the lines of the New York, Ontario, and Western and the Ulster and Delaware railroads. All these quarries are probably in the Catskill group. The quarries at Westfield flats and near Trout Brook and East Branch are near the New York, Ontario, and Western railroad. The stone is a rather coarse grained sandstone or grit of a grayish to a greenish-gray color, thus differing from the darker and finer-grained blue-stone of the Hamilton formation. Various openings have recently been made in this region along this line of railroad.

At a quarry near Margaretville the depth of stripping is 8 feet, and the blocks, as limited by the natural joints, are very large. The product is carted to Hartville station, on the Ulster and Delaware railroad, and from there transported by rail to Rondout. A quarry has been opened near Halcottsville. The beds here so far as developed are from 1 inch to 4 inches thick and the depth of stripping is 8 feet. The joints are vertical and very regular; the stone is reddish in color and rather coarse grained; blocks 15 by 6 feet have been taken out, and larger sizes might be obtained.

The quarries in the vicinity of Roxbury are also near the line of the Ulster and Delaware railroad. In a quarry about 1 mile from Grand Gorge station, 70 miles from Rondout, the workable beds are 12 feet in thickness and the depth of stripping is about 30 feet. The stone has a grayish color and is coarse grained.

In Otsego county both the Hamilton and the Chemung groups are quarried in a quarry located on the east side of Otsego lake and about 70 feet above it. The jointing is rectangular, the beds are even, and the depth of stripping is 8 feet. The stone is soft, works easily when first quarried, and hardens on exposure. Where used for steps for a number of years it has not worn smooth, and shows considerable durability. At present this quarry supplies only the local demand for foundations and general building purposes.

The quarry at Oneonta supplies the local demand for flagging and cut work.

In Chenango county there was formerly quite an extensive quarry industry at Guilford, but at present only one quarry is in operation. The market for this stone is at Syracuse. Blocks of large bed dimensions may be obtained here, but the layers are rather thin. The quarry at Smithville flats is also remarkable for the large size of the blocks between the joints, and some of the layers are 2 feet in thickness. The aggregate thickness of workable beds is about 12 feet, and the depth of stripping is about 15 feet, but it is mostly loose material and easily removed. The stone is shipped principally to New York city for flagging and building purposes; but it has to be drawn on wagons to Greene, 8 miles distant, on the Utica division of the Delaware, Lackawanna, and Western railroad.

In Oneida county the Oneida conglomerate quarried near New Hartford is hard and difficult to dress, and therefore is used only for bridge work and foundations. The quarry at Camden is probably in the Medina sandstone, but the formation has not been well identified. The stone is light gray in color and rather coarse grained; the layers near the surface are thin, and are used for flagging, but they increase in thickness as the quarry is worked downward. The stone is used to supply local demands, and some is shipped to Oswego and neighboring towns.

The quarry near Atwater, Cayuga county, is in a good flag-stone stratum, but its distance from the nearest railway station and the depth of cap-rock to be removed prevent its extensive development.

The Tompkins County quarries are worked chiefly for flagging. The quarry at Ithaca supplies the local demand, and the one at Trumansburg supplies flagging for the town of Geneva and some for Ithaca. The layers in these quarries are rather thin, but large blocks can be obtained. The quarries at Covert, Seneca county, also furnish flagging, which is at present used mainly at the towns of Geneva, Waterloo, and Auburn. The quarries are located but a short distance from railroad and water transportation.

The quarry at Watkins, Schuyler county, is a fine-grained, evenly-bedded blue sandstone. The stone is used along the line of the North Central railroad for general construction purposes, and it seems to be well adapted for

heavy bridge construction. No good building stone is found on this line of railroad either north or south of this point for a considerable distance, and the stone from this quarry is used southward on the railroad as far as Williamsport, Pennsylvania.

The Steuben County quarries furnish stone for general building purposes, mainly for local demands. The stone dresses easily, but it is not a safe stone to use, because it is liable to disintegrate. The demand in this county for good stone is supplied from distant quarries, and flagging has been furnished quite largely from Mainsburg, Tioga county, Pennsylvania.

The quarry district in the Medina sandstone extends from Brockport, Monroe county, to Lockport, Niagara county. The stone is very hard, and therefore seldom used for cut work. There is a light gray and also a reddish variety, the latter has a bright and pleasant appearance both in dressed and in rock-faced work, and both varieties are sometimes used together with good effect, but the red is used more than the gray for buildings. Most of the stone buildings in Lockport and in Buffalo are of Medina sandstone. Perhaps the most important feature of this stone is its special applicability for street pavements. It was first introduced for this purpose in Cleveland, Ohio, and it is now used in many cities and towns from New York to Kansas City. The blocks are made of the same size and shape as the granite paving blocks; they do not wear smooth, and are nearly, if not quite, as durable as granite blocks. The stratum of quarry rock is about 30 feet in thickness, and the thickness of the layers varies from $2\frac{1}{2}$ to 18 inches, the thinner ones supplying an excellent material for paving sidewalks.

The remaining quarries in the state of New York are small and supply local demands. The stone is of an inferior quality, except in the Belfast quarry, Allegany county, where it is of good quality, though so far from any route of transportation that it cannot be worked for anything but local use.

MARBLE.

Tuckahoe marble.—The quarries which furnish this are, according to Newberry, in one of the belts of dolomite of Archæan age which lie to the north of New York city, and cross the country in a north-northeast direction. One of these belts reaches New York island, crossing the Harlem river at Kingsbridge; another crops out on the sound near Rochelle; others strike the river at Hastings, Dobbs Ferry, Sing Sing, and other points, and furnish stones good for construction purposes and of varied colors. The best marbles obtained from these deposits are those of Tuckahoe and Pleasantville. The first is white, rather coarse in texture and regular in quality, and the better grades have been used for some of the finest buildings in the city of New York, notably Saint Patrick's cathedral. The color changes to light gray by exposure.

At the quarry of the Tuckahoe Marble Company the finest grade is nearly a pure white, but this is available only in small quantities, and is used for monumental and ornamental work. In Mr. John F. Masterdon's quarry this same material is quarried more extensively.

In composition the stone from these quarries is a dolomite, containing a small amount of iron and some mica. The buildings constructed of the stone from the Tuckahoe Marble Company's quarry are those of the New York Stock Exchange, New York city, and the Mutual Life Insurance Company at Boston. Those constructed of the material from Mr. Masterdon's quarry are the New York Life Insurance building, New York city, the city hall, Brooklyn, New York, and the hotel Vendôme, Boston.

At Pleasantville, a few miles north of the Tuckahoe quarries, a coarse, crystalline white marble occurs; formerly this was quite extensively quarried for building purposes. The front of the Union Dime Savings Bank building in New York city is built of this stone. Its structure being quite coarse, it is not well adapted for carved work. It has also been found to break easily, especially when used for long columns; and it would not be a safe stone on this account for all kinds of work. The stone is remarkable for its crystalline appearance, the crystals being usually large and conspicuous, and, from this peculiar appearance, it has received the name of "snow-flake" marble. This quarry has recently been furnishing about 25 tons of stone per day for making soda water.

At Dover Plains and South Dover are three other marble quarries, the stone from which also shows a coarse structure and is easily broken.

A quarry of bluish-gray limestone was opened in November, 1880, at Clinton Point, about 5 miles south of Poughkeepsie. The material that has been extracted has been used for bridge abutments at Newburgh.

At Greenport, Columbia county, Mr. F. W. Jones' quarry is worked on a stratum from 60 to 70 feet in thickness. Blocks of any desired dimensions may be obtained. The stone is employed for general architectural and ornamental uses, principally at Hudson and Troy, New York. The Presbyterian church at Hudson is constructed of it. It is a nearly pure limestone, containing some protoxide of iron and a little magnesia. The quarry of the Kingsbury Blue Stone Company at Sandy Hill, Washington county, is located on a branch of the Champlain canal and near the railroad of the Delaware and Hudson Canal Company, and has superior facilities for transporting the material to market both by canal and by railway. The quarry proper covers an area of 40 acres. A face half a mile in length and 30 feet in height is opened. The stone is very nearly a pure limestone, containing a very small amount of iron, a little magnesia, and a little siliceous matter. It was used in the construction of most of the locks upon the Champlain canal and the city dam at Cohoes, and it is now being used for the construction of the Harlem bridge for the West Side and Yonkers Elevated railway.

The quarry of Mr. Prince Wing, near Saratoga, has been worked for many years, stone for burning lime having been taken out before 18 0. The lime produced from it is very white and of excellent quality. In composition it is almost a pure limestone, containing very little magnesia and some graphite. It is used for general building purposes and for flagging, mainly at Saratoga and Ballston, New York.

The quarries at Glens Falls are worked on both sides of the Hudson river, which breaks through the formation at this point. The same formation crops out a short distance east of this place, is crossed by the river, dips under the overlying formation, and disappears just above the falls. On the south side of the river there are three distinct strata of limestone: the upper one, about 12 feet thick, being overlaid by about 15 feet of rough limestone and some slate. It is fine grained and makes a good material for cut work. Below this is a stratum of about 15 feet of the slaty-structured stone, and then a stratum 2 feet in thickness of a coarse crystalline limestone. Below this occurs the valuable black marble bed, about 12 feet in thickness. From this a large amount of tiling is manufactured. The stone is taken out in large blocks, and is either sawed and rubbed in the mills at the quarry or is shipped in the rough, mainly to the neighboring cities and to New York. The tiling and material for ornamental purposes go to all the principal cities in the United States. The stone is shipped both on the Champlain canal and the Delaware and Hudson Canal Company railroad. It is a limestone in composition, containing a little magnesia, some iron, and some graphite. None of the products of the lower stratum are allowed to go to waste, though a very large proportion of the material is not suitable for architectural or ornamental work. A large amount of the marble of the lower bed on both sides of the river is burned in the extensive kilns of the Glens Falls Company, and produces the so-called "Joints" lime of remarkable purity. The stone is quarried by blasting, and, therefore, much of it is shattered so as to be fit only for burning. The slaty-mixed limestone of some of the layers and of the stripping was formerly used for flux in the iron furnace at Fort Edward, New York.

On the north side of the river, where the quarry of the Glens Falls Company is located, the two upper strata above mentioned do not occur. The formation has here been worked to an average depth of about 30 feet and 60 feet in width for a distance of half a mile eastward from Glens Falls.

The next point to the north of Glens Falls where the Trenton limestone is quarried is at the quarry of Mr. Frank Clark, near Crown Point, Essex county. In general appearance and composition this stone resembles that of Glens Falls, but its texture is finer and more brittle. It is used for curbs, trimmings, and various kinds of cut work, principally at fort Henry, Plattsburgh, Saratoga, and Schuylerville. The rock is considerably fractured, and large blocks suitable for sawing cannot be readily obtained.

Of the marble and limestone deposits on the west shore of lake Champlain only two localities have been extensively developed, one at Willsborough, Essex county, and the other at Plattsburgh, Clinton county. The quarry of the Lake Champlain Quarry Company is located on the extreme northeast portion of Willsborough point; it is well equipped and favorably located, the blocks being swung by derricks directly from their beds to the decks of the boats used for transporting the material to market. The stone is, for the most part, a fine-grained, compact, blue limestone, containing fossil remains; the different layers differ slightly in color and texture. Formerly a large amount of this stone was shipped, but during a few years past the demand has been much lighter. It was used in the foundations of the piers of the East River bridge, and in the foundations of the new capitol at Albany. There are several layers worked which are separated by thin seams of clay; large-sized blocks can be obtained, and the stone is worked into all kinds of cut work and can be sawed and rubbed. Some of the layers furnish a fine black marble, which is susceptible of being highly polished, and it is used for various kinds of ornamental work. The rock comes to the surface and no stripping is necessary. The formation dips east of north under the lake. A porphyritic dike crosses the formation from east to west; it is from 12 to 14 feet wide and exceedingly well marked, extending from the shore of the lake until lost beneath the soil beyond the quarry.

The quarry of the Burlington Manufacturing Company is located near lake Champlain and not far from Plattsburgh. Large blocks are channeled out and shipped by boat to Burlington, Vermont, where they are sawed, and from the slabs all kinds of ornamental work are produced. Two varieties of limestone occur at this point, and are known in the trade as French-gray and Lepanto marbles. The latter is beautifully variegated with red and gray, and is largely made up of fossil remains, which give a beautiful appearance to a polished surface. The variegated marble is quite extensively used for inside decoration in public buildings, often in connection with white marble. It is shipped, for mantels, tiling, table-tops, and general decorative work, to all parts of the United States. Another marble quarry has recently been opened by this company at fort Henry, Essex county. This marble is composed of a ground mass in which are patches of serpentine, numerous crystals of pyrrhotite about one-eighth of an inch in diameter, and some graphite scales.

The quarry of the Gouverneur Marble and Whitney Granite Company is situated one mile west of Gouverneur, Lewis county. The limestone is crystalline and lies immediately on the granite; in fact, in some places the granite overlies the limestone. The surface is glaciated and rubbed smooth. It is usually called "Whitney granite", on account of its close resemblance to several kinds of gray granite when polished or finished with a patent hammer; but it is properly a marble, being, however, too coarse-grained to be finely carved. There is reason to believe that it will withstand the action of the weather, as head-stones in this immediate vicinity have been standing from 40 to 70 years. In the Riverside cemetery at Gouverneur there are about one hundred of these

old head-stones; they present a good, clean, uniform surface, are very free from moss or any discoloration, and the corners and arrises are sharp and perfect. This marble is easy to work and takes a very fine gloss, and, being dark colored when polished and white when chiseled, any scroll-work or tracing makes a nice contrast. Much of it is finished with a patent hammer, some partly patent-hammered and partly polished, or polished and margined.

On account of the thickness of layers in the quarry, dies can be furnished 7 feet high that will stand on their natural bed and be of good uniform color. All dies 18 inches square or over are quarried to stand on their natural bed. Smaller sizes are quarried the other way.

The entire limestone formation is marketable stone, and there is no cap-rock to be removed. The upper portion, which is coarsely crystalline, is used for building purposes. Farther down the grain is finer and the color darker, and most of this is shipped directly to Cleveland, Ohio, and to New York city, where it is sawed and manufactured.

In this locality there are several quarries of the same stone now being opened. An excellent quality of granite is also found here, but as yet has not been worked. Soap-stone is also found in workable quantities, and asbestus appears. A large variety of serpentine is found in this locality, though as yet none has been put into the market.

A quarry at the head of Three-Mile bay, Jefferson county, is favorably located for water transportation. The rock is a rather hard, compact limestone, but works quite well for fine cut work. Two varieties, blue and gray, are used. Several quarries have been opened in the same formation at Chaumont, a few miles from the Three-Mile-Bay quarry, and on the Rome and Watertown railway.

A quarry at Lowville, Lewis county, in the cliff of Trenton limestone caused by Mill creek cutting across the formation at this point, has a face of nearly 90 feet, which is almost the entire thickness of the blue limestone in this section. It furnishes an excellent building stone, for local demand mainly, and also stone for flagging and curbing.

A quarry in a gorge through which the Sugar river passes, at Talcottville, Lewis county, can be worked with the least possible amount of labor and expense. The stream has cut through the ledge and left cliffs of solid stone 30 or more feet in height in an exposure of a quarter of a mile or more. All of this is valuable stone. The top layers are used for lime and the lower ones for building stone. The layers are from 3 to 15 inches thick, and furnish an excellent working stone, making good cut work. Between the layers of stone are thin layers of slate. Marine fossils are found in abundance. Formerly large amounts of stone were sent from this quarry to the towns along the Utica and Black River railroad, but at present the building stones taken out are used in the county. The jointing of the formation at this point is remarkably regular, and the layers of the bed are free and easily separated. No other quarries of any importance are opened in this vicinity.

At Canajoharie, Montgomery county, an extensive ledge of Trenton limestone occurs south of the Mohawk river. Quite a variety of stone is obtained in the different layers in the quarry worked at this point. The topmost layer is a hard, rough, somewhat calciferous sand-rock, and below this is a gray rock, gray limestone, etc. The layers vary in thickness from 2 feet downward. Only the gray limestone is dressed, and the sand-rock is used quite largely for foundations; a number of the houses in the town of Canajoharie are built of it. The stone from this quarry is also shipped to Utica and Little Falls; at the former place it was used in the construction of the steam cotton-mills and the Mohawk River Valley mills. Farther down the Mohawk river, at Tribes Hill, the Trenton group is partly cut through, and valuable building stones are obtained on each side of the stream. The quarries here produced in former years much of the stone used in the construction of bridges on the New York Central and Hudson River railroad, and much of that used in building the locks of the Erie canal. The locations of these quarries are convenient for transportation, those on the north of the river being on the line of the New York Central railroad, and those on the south on the canal banks. The stone is strong, compact, and durable, and is little affected by atmospheric action, though some of the strata which occur here are not valuable for building stone. At the top occurs a shell limestone; below this a stratum of gray limestone about 4 feet in thickness, then a dark blue limestone 7 feet in thickness, then a stratum, about 4 feet in thickness, of rough, hard, thinly sandstone, somewhat calciferous, and below this is the stratum which furnishes the best stone. This last has been worked to a depth of 28 feet, and the bottom has not yet been reached.

About 1 mile north of Amsterdam, Montgomery county, there are two distinct strata of stone quarried, differing in color and quality, that of the upper stratum being quite largely burned for lime, and also used for cut work; the lower stratum is more brittle. The layers are from 4 inches to 2½ feet in thickness; the weathered portion of the top is burned. Most of the product of these quarries is used to supply local demands, though some of it has been shipped for use in important structures, including the New York Central Railroad bridge at Albany, the Cohoes dam, and the state capitol.

At Sharon Springs, Schoharie county, is a dark-colored, firm limestone, in beds varying in thickness from a few inches to 2½ feet. The thin beds are used in the vicinity for paving sidewalks. The stone, though quite hard, dresses easily, and is used for general architectural purposes, though mainly to supply the local demand. This quarry has been worked at intervals for many years past, but during the last eight or nine years it has been worked but little, though the stone is of superior quality, and might form the basis of an extensive industry with sufficiently low rates of transportation.

Near Cobleskill the Corniferous formation occurs in strata of cherty limestone, and gray and blue limestone, separated by layers of chert nodules. The stone dresses quite well, and is used for buildings and monumental work.

Just south of Howe's cave there is a high cliff of limestone of the Lower Helderberg formation, in which the quarry of the Howe's Cave Association is located. The total height of the escarpment above the valley bottom is about 150 feet. The vertical section of the quarry is as follows:

	Feet.
Gray stone, used for heavy work	15
Gray and black stone mixed, used for ballast	12
Blue limestone, building stone	10
Shaly beds, used for ballast	10
Blue limestone, building stone	6

The heavy gray limestone is taken out in large blocks and is used chiefly for the construction of bridge abutments. It is not susceptible of being polished and is not well adapted to fine work. The blue limestone dresses well, and the material readily finds market along the line of the Albany and Susquehanna railroad. A considerable quarry industry has been built up at this point, owing to the excellence of the stone, especially for heavy masonry, and to the convenience in working the quarry due to the slight amount of cap rock to be removed, the height of quarry face, and natural drainage. There is also an advantage gained from the fact that the material which, for one cause or another, is not suitable for building stone is broken up and used for railroad ballast.

The Onondaga limestone occurs in beds from 1 foot to 2½ feet in thickness. One mile north of the village of Springfield Center, Otsego county, on the west side of the outlet of Summit lake, the quarry of Messrs. McCabe & Brothers is located. The top of the limestone is polished and grooved by glacial action, and is covered by from 15 to 30 feet of glacial drift. This covering of clayey and calcareous drift has protected the stone against atmospheric influences, and no discoloration has taken place. The rock has a bluish color, which on exposure becomes somewhat lighter. The massive character of the stone makes it suitable for heavy work, and it also seems to possess the properties of strength and durability; however, no examples are known where the stone has been exposed for a very long time to test its power of endurance. Several buildings have been constructed of it, including the Otsego County jail, and the hotel Fenimore, at Cooperstown.

In Onondaga county the Onondaga limestone was formerly quite extensively quarried, during the period of the rapid development of the country. The quarries at Onondaga are within the Indian reservation, and furnish an excellent quality of stone; but the amount of cap-rock to be removed is considerable, being from 16 to 18 feet, and the lack of facilities for transportation prevents an extensive quarry industry. The stone is used for buildings and monuments chiefly at Binghamton and at Syracuse; in the latter place the university building, the court-house, and Saint Mary's church are built of this stone.

The quarries at Fair Mount and Manlius were first opened to obtain stone for locks on the Erie canal. In this vicinity there were formerly also a greater number of quarries than at present, and the demand for the stone is still gradually diminishing. The beds are not so heavy as those at Onondaga; they are here from 8 to 12 inches thick, and at Onondaga some layers are 4 feet in thickness. Fine exposures of the Tully limestone also occur in some localities, but it is not found in places where facilities for transportation are afforded, and has therefore not been at all developed.

The quarries at Auburn, Cayuga county, supply the local demand for general construction purposes, and some of the gray limestone from the quarry of Mr. John Bennett has been used for monuments. Some quarries are also worked in the vicinity of Auburn for stone used in macadamizing roads, and some for lime. The rock is nearly a pure limestone, containing a little magnesia and iron.

At Union Springs the Seneca blue limestone is quarried principally for railroad work along the line of the Delaware, Lackawanna, and Western railroad. The stone is suitable for bridge construction and other heavy masonry in which undressed stone may be used, the beds being even, some of them 20 inches in thickness, and the blocks being readily broken out in rectangular shapes. This limestone contains little magnesia, some graphite, and some protoxide of iron.

A favorable development of the Onondaga limestone occurs at Waterloo, Seneca county, on the Erie canal. The quarries at this point were opened when the canal was built, and have been worked more or less ever since. The stripping is from 5 to 8 feet, and the limestone has been quarried out to a depth of from 18 to 22 feet. The stone is used chiefly at Rochester for general construction purposes. At Rochester the Niagara limestone occurs in broken strata and is quarried for rough foundations. The stone is easily accessible, being covered with only 2 feet of loose material, and conveniently supplies the local demand for foundation stone.

At Le Roy, Genesee county, the Onondaga limestone is quarried for the Elmira market, chiefly for foundations and for bridge work on the Erie and State Line railroad. The stone is too hard to dress, and is used only for rough masonry. Some stone has also been quarried in this vicinity for blast-furnace flux.

At Lockport, Niagara county, the Niagara limestone has been quite extensively quarried for many years for general construction purposes, and the stone has been shipped to New York, Buffalo, and Rochester. In some years the value of the product sold has reached $400,000, but the demand for this stone has diminished in the last few years. The quarry is favorably located for transportation both by canal and by railroad.

The corniferous limestone crops out quite extensively in the vicinity of Buffalo and within the city limits. The quarries at Williamsville, about 10 miles northeast of Buffalo, are worked for the Buffalo market, producing material for ordinary purposes of construction, and some stone suitable for sawing and polishing, which is manufactured for ornamental purposes, principally table-tops and mantels. The Buffalo quarries supply most of the stone for rough masonry, such as cellar walls, foundations, cribs, piers, and general railroad work in the vicinity of Buffalo. It is not adapted to cut work.

A number of quarries which do not appear in the tables are worked at intervals in this vicinity. The deepest of the quarries have been excavated about 30 feet in depth, and several acres in area have been taken out. A considerable amount of lime is manufactured in the quarries of the corniferous limestone in Erie county. The rock is nearly pure limestone, containing small quantities of magnesia and iron, and very little siliceous matter.

NEW JERSEY.

[Compiled mainly from notes by Professors Cook and Smock.

ARCHÆAN GRANITE, GNEISS, AND MARBLE.

The gneisses make up the great mass of the Archæan outcrop. The areas of granite and of crystalline limestone are comparatively small, and are confined to the highlands in the northern part of the state, in Sussex, Warren, Morris, Hunterdon, Passaic, and Bergen counties. The Morris canal, the Delaware, Lackawanna, and Western, the Central New York, the Susquehanna and Western, the New York and Greenwood Lake, the Belvidere Delaware, and the Sussex railroads all traverse the district. The New York, Lake Erie, and Western and the new Lehigh and Hudson railroads also run close to outcrops of these Archæan rocks. The facilities for easy transportation to large cities and towns are good.

The beds of gneiss are in many places very regular, and the stone is generally free from pyrite, magnetite, or other injurious constituents; but care is necessary to avoid these minerals, as they are found widely distributed. Granite is not common, except in small masses, and the outcrops are too limited for quarrying.

LOCALITIES WHERE GRANITE QUARRIES HAVE BEEN OPENED.

1. Near Franklin Furnace, Sussex county. *Geology of New Jersey*, p. 503.
2. Port Murray, Warren county. *Geology of New Jersey*, p. 503.
3. Dover, Morris county. *Geology of New Jersey*, p. 502.
4. Bloomingdale, Passaic county. *An. Rept.*, 1873, pp. 99, 100.
5. Near Charlotteburg (granite), Passaic county. *An. Rept.*, 1873, p. 100.

MARBLES.

1. Warren Marble quarry, Warren county. *An. Rept.*, 1872, p. 26.
2. Marble mountain, Warren county. *An. Rept.*, p. 28.
3. Rose Crystal Marble quarry, Warren county. *An. Repts.*, 1872, p. 27; 1881, p. 42.

A white limestone has been quarried near Stanhope, in Sussex county, but without much success, as the mass appears to be traversed by seams.

REFERENCES TO GENERAL DESCRIPTIONS OF GNEISS LIMESTONE.—*Geology of New Jersey*, 1868, pp. 64, 312, 316, 319, 321, 502; *An. Rept.* for 1873, p. 101; *ibid.*, for 1881, pp. 41, 42; *ibid.*, for 1879, p. 104 (Mendham limestone).

The only locality in New Jersey where gneiss has been quarried uninterruptedly for any considerable period is at Dover, Morris county, on the Delaware, Lackawanna, and Western railroad. The material is quarried for bridge construction and general work for the railroad company's use exclusively. Quarries in the other gneissic-rock localities in the state have all been abandoned after short periods of working. The convenient location at the side of the railroad track, the very light stripping, the facility with which the stone can be quarried, and its excellence as durable and solid stone for heavy work make this quarry a profitable one. The direction of the outcrop is northeast, and it is cut by the new High Bridge railroad a few rods from this quarry.

The New Jersey Central Railroad Company proposes to open a quarry near the railroad in the same hill. With the two lines of railroad and the Morris canal all crossing the ledges, the transportation facilities are unsurpassed. The great amount of stone which can be obtained in the clearing of ground for agricultural purposes in this neighborhood and in northern New Jersey generally has retarded the development of quarries in the gneissic rocks of this part of the state. As the country becomes more cleared and the land more valuable, these sources of supply are gradually restricted and other quarries similar to the Dover quarry will be developed. For ordinary foundation work and for cellar walls, bridges, wharves, and work of that class, the supply is inexhaustible, and stone can be furnished at comparatively low rates. The use of the gneissic rocks of New Jersey is increasing, as they are excellently adapted from their strength and durability to many purposes.

POTSDAM SANDSTONE AND GREEN POND MOUNTAIN CONGLOMERATE.

The sandstone considered of Potsdam age occurs in narrow outcrops bordering at intervals the gneisses. For localities see *Geology of New Jersey*, pp. 71–79. A little less has been quarried at (1) Franklin Furnace, Sussex county; (2) Danville, Warren county; (3) Oxford Furnace, Warren county; and (4) in the Pohatcong valley, near Washington, Warren county.

The sandstone of the Green Pond mountain belt (of Potsdam horizon) has been quarried on Kanouse mountain (near) 1, Newfoundland, Passaic county; (near) 2, McCainsville, Morris county.

REFERENCES ADDITIONAL TO ABOVE.—*Geology of New Jersey*, pp. 503, 504; *An. Rept.*, 1872, pp. 28, 29; *ibid.*, 1881, p. 42.

The Green Pond mountain conglomerate has been used with good effect at Morristown and at Boonton, but the bowlders of the country around the towns have furnished an adequate supply. The same stone can be obtained at many places in Morris and Passaic counties. It can be had in blocks of any size capable of easy handling. The stone is very hard and solid, and free from all minerals other than quartz; and the sharp, angular edges and numberless glacier-polished bowlders which have been exposed to the weather for ages attest its ability to resist atmospheric agencies; but it is not easy to dress on account of its excessive hardness. The quarries in this formation were not in operation during 1880.

MAGNESIAN LIMESTONE.

This rock is the predominating limestone of the state, and is found in Hunterdon, Warren, Sussex, Morris, and Somerset counties. For the localities see *Geology of New Jersey*, pp. 9–130; also map. It has been opened at many points for stone to be used in lime manufacture. For building purposes the localities in which this stone is found are numerous, particularly in Sussex and Warren counties; and it is in general use in these counties, and in parts of the adjoining counties of Hunterdon, Somerset, and Passaic, for building foundations, and for buildings of all kinds. For heavy bridge work it is used largely. The railroad and canal companies use a great deal of it in heavy construction. (See *Geology of New Jersey*, pp. 513, 514 and 392–396; *An. Rept.* for 1873, pp. 100, 101; *ibid.*, 1881, p. 41; also schedule of Newton limestone.) For analyses see above references and *An. Repts.*, 1875, p. 36; 1876, p. 55; 1878, p. 104.

HUDSON RIVER SLATE.

This rock yields the roofing slates. The principal quarries are: (1) La Fayette, Sussex county; (2) Newton, Sussex county; (3) Delaware Water Gap, Warren county.

REFERENCES.—*Geology of New Jersey*, pp. 135–145 and 518–520; *An. Rept.* for 1872, pp. 29, 30. The flagging stone of Flag-stone hill, Wantage township, Sussex county, belongs to this geological horizon. *Geology of New Jersey*, 1868, p. 522: Flag-stone; *An. Rept.*, 1881, pp. 64–66.

The only quarries of roofing slate in New Jersey that were operated to any considerable extent in 1880 are those near La Fayette, Sussex county. They are within a mile of the Sussex railroad, and but little farther from the new line of the New York, Susquehanna, and Western railroad. These quarries dip to the northwest. The geological horizon is that of the Hudson River slate. The reputation of the La Fayette slate is good; the color is usually a blue-black.

ONEIDA CONGLOMERATE AND MEDINA SANDSTONE.

These rocks constitute the mass of the summit and western slope of the Kittatinny or Blue mountain, stretching from the Delaware Water Gap to the New York state line. They have not been opened by any regular quarries, although the outcrops are many and the stone of the conglomerate formation is solid and durable, and can be had in quite regular beds. The sandstone is, in most places, too slaty and shaly in structure to make a good building material. The only quarry or opening worthy the name is in Sussex county, and in Montague township, where the red stone is got out in thin beds of large size; but it is not near transportation. (*Geology of New Jersey*, 1868, pp. 146, 149, 513.)

LOWER HELDERBERG LIMESTONE GROUP.

The rocks of this group are found in place in a narrow belt in the valley of the Delaware from near Port Jervis to the Nalpack bend, and are confined to Sussex county alone. They are quarried extensively for lime manufacture, but not for building, except a little which goes to Port Jervis and the adjacent country. The quarries are in Montague township, Sussex county.

UPPER HELDERBERG GROUP—ONONDAGA AND CORNIFEROUS LIMESTONES.

The above-mentioned belt in Sussex county is bordered on the west and northwest by the very narrow belt of Oriskany sandstone and Cauda-galli grit (both unfit for building material), and these latter are followed by the Onondaga and Corniferous limestones in a very narrow outcrop bordering the alluvial plain of the Delaware river.

They have yielded considerable stone for this part of the Delaware valley, which is used for bridge piers, abutments, dwellings, etc., but there are no large and regularly-worked quarries. The outcrops are many, and no excavation is generally necessary to meet the occasional demands of the valley.

REFERENCES.—*Geology of New Jersey*, 1868, pp. 165, 166, 514.

TRIASSIC AGE—SANDSTONE, FREESTONE, AND BROWNSTONE.

The most noted quarries in the state and some of the largest in the country are opened in the sandstones of the Triassic age. The formation occupies a broad belt of the state, running from the New York line southwest to the Delaware river. Its boundaries are shown by the geological maps of the state. For general descriptions of its rocks, see *Geology of New Jersey*, 1868, pp. 206–225; also *An. Rept.* for 1879, pp. 18–35.

The Little Falls, Paterson, Belleville, and Newark quarries are the most celebrated of any on the eastern side of the state. In the central part of the belt there are quarries in Washington valley (north of Plainfield), at Martinsville and Princeton.

Along the Delaware river there are large quarries at Greensburg, 4 miles above Trenton, and farther up the river valley at Stockton and Prallsville. The localities where quarries have been opened are given in the *Annual Report of the New Jersey Geological Survey* for 1879, pp. 21, 25. There are other places where stone has been quarried, but the above list includes those which have been worked for sale of stone.

The principal building stone in Newark, Paterson, Orange, Elizabeth, and New Brunswick comes from the Belleville and Newark quarries. They furnish a large quantity of very superior building stone to New York city. The new Mills building in that city is one of their monuments. Trinity church, New York, represents Little Falls. In beauty of shade, solidity, and durability the selected stones from the Little Falls, Belleville, and Newark quarries are unsurpassed. It is not superfluous to add that the stone of these quarries is the best of the New Jersey sandstones or freestones. It is not so micaceous as many other sandstones, and has not their laminated structure; hence for ornamental work it is well adapted. The absence of bedding lines admits of less care in laying it up. Some horizons are more argillaceous, and so-called "clay-holes" are observed in them.

The Belleville quarries are at North Belleville, and on the right, or west, bank of the Passaic river. They are located on a nearly north and south line, and are about 100 yards distant from the river front, which affords wharfage room for vessels of moderate size, as the tide comes up to this point. The railroad line (Newark and Paterson branch of the New York, Lake Erie, and Western railroad) runs nearly parallel with the river and about a quarter of a mile west of the quarries. There are three different openings. The following are some of the principal buildings in which this material has been used: Fort La Fayette, New York harbor; Stevens' house, Fifth avenue and Fifty-seventh street; Ruppert's house, Fifth avenue and Ninety-third street; building corner of Madison avenue and Twenty-eighth street; the Mills building, on Broad street, and A. T. Stewart's buildings, New York city.

There is considerable variation of the strata in the different parts of the quarry. In the southernmost of these quarries the glacial drift is 20 feet thick; then there is a thickness of 30 feet of red, fine-grained sandstone, most of which is of inferior quality, and the best of it is only fit for foundations, cellar walls, etc. Under this thickness comes next a coarse-grained, thickly-bedded, reddish-gray sandstone; beneath the latter is a fine-grained red sandstone, which can be rubbed and polished. The reddish-gray stone is equally durable, and looks well, but it cannot be rubbed. The former brings $1, the latter $1 50 per cubic foot. Explosives are used mostly for throwing down the top stone. Canisters or conical charges of black powder are always employed in working off blocks of the best and most valuable stone. There are disadvantages of considerable stripping. Working in the direction of the dip, water must be pumped out, as all of the quarries are below tide-level in the deepest points, one of them being 35 feet below the Passaic River level (tide).

Near Avondale station, Belleville, is a quarry of this material which was opened about the time of the Revolution. The principal markets now are Newark, New York, and Brooklyn. The ledge here extends S. 5° W., the strata being vertical. At the west end of the quarry there is a fine-grained chocolate-colored stone at the top, under several feet of stripping. The light-colored stone is a coarse, granular mixture of quartz and feldspar. The shade of color is very pleasing and the stone is solid, occurring in thick beds. It was used in the construction of the Presbyterian church, Fifth avenue and Fifty-fifth street, New York city, and of various bank buildings in Newark.

In one of these quarries the total area of the opening is at least 5 acres, being about 500 feet square. The vertical section on the northwest includes 60 feet of stripping, of which one bed 3 feet thick can be used for cutting into stone for foundations and cellar walls. Then there are 20 feet of the thick and solid beds of grayish, coarse-grained stone at top, and fine red stone used for rubbing at the bottom; underneath the latter there is an excavation 14 feet into a shaly rock. These varieties are sometimes designated "No. 1" and "No. 2" stone, respectively. On the south side of the quarry there are only 20 feet of stripping, and then comes solid stone. A fault traverses this quarry in a north and south direction, displacing the beds to the extent of 4 or 5 feet. Its plane dips 65° to 70° west. This fault also appears in one of the neighboring quarries.

On the south side of Bloomfield avenue, Newark, is located one of the principal quarries. The opening is at least 400 feet long from north to south, and the quarry progresses west and northwest in the line of the dip. The

stripping consists of earth and shaly rock, and varies in thickness from 10 to 30 feet. The dip is very uniformly in a west-northwest direction and at a slight angle. The joints show no apparent system. On the west the vertical section is approximately as follows, beginning at the top:

	Feet
1. Glacial drift	12
2. Shaly rock	15
3. Shaly beds	1 to 4
4. Dark-colored red sandstone	6
5. Callous	1
6. Light-colored sandstone, thick beds	8 to 15
7. Callous	3 to 4
8. Dark-colored harder sandstone	4 to 6

In the glacial drift the material is mostly red shale. Nos. 4, 6, and 8 are workable horizons. At the south end of the quarry the stripping is only 10 feet thick. Very little powder is used. Stone is wedged off and split up after the top or stripping has been removed. One engine works both derricks, and the pumping is done by a small engine. The material from this quarry has been used for the construction of the Collegiate Reformed church, Fifth avenue and Forty-eighth street; the Saint Thomas Protestant Episcopal church, Fifth avenue; the Jewish synagogue; Presbyterian church, Lexington avenue; Reformed Episcopal church, Madison avenue; Trinity Church school, Church street—all in New York city; Saint Peter's Episcopal church, Albany, New York; La Fayette College buildings, Easton, Pennsylvania; Yale College buildings, New Haven, Connecticut; Princeton College buildings, Princeton, and Kirkpatrick's chapel, Rutger's college, New Brunswick, New Jersey, and many other buildings, especially in Newark.

The Newark quarries are all conveniently located for transportation. There is natural drainage, as the quarries are on a ridge or the highest ground in Newark, which is 100 feet above mean tide-level. The thickness of workable strata, the pleasing shades of color, and the fine texture and evenness of grain are circumstances very favorable to these quarries, but the value of the land for building purposes is high.

In the quarry between Fifth and Sixth avenues the strata quarried are remarkable for their thickness and solidity, and the joints are wide apart. One system of joints runs northeast and southwest, and is clean and open. The glacial-drift covering is about 30 feet thick, but varies to 10 feet in thickness in places. The quarry is nearly square, having sides about 200 feet in length, and the stone worked has a total thickness of 30 feet. At the bottom a shaly rock is found. Very large and solid blocks can be quarried here, and some of the more solid rocks show no signs of stratification.

The following are some of the principal buildings in the construction of which this stone was used: The college dormitory and the Marquand chapel, Princeton, New Jersey; Trinity chapel, Houston street; Saint Jerome's church spire, and the trimmings of buildings on the corner of Thirty-second street and Broadway, New York city.

At the corner of Bloomfield and Prospect avenues is an old quarry formerly worked very actively, but it is about to be closed, as land here is considered too valuable for quarry purposes. The quarry has a length of 700 feet and is 300 feet wide and 60 feet deep at the deepest point. The glacial drift covering is on an average 15 feet thick. On the north side there are two workable horizons each 12 feet thick and separated by shaly beds 3 feet in thickness. The location is northeast of that of the Newark Quarry Company, and crosses Bloomfield avenue about 150 yards away.

A short distance west of this quarry, and on the same excavation, a new quarry was opened in 1880. The excavation measures 50 by 50 feet and is 40 feet deep. The beds are covered to a depth of from 5 to 8 feet by glacial drift. The ledge here opened is shaly at top, and there is first a thickness of from 10 to 15 feet of red sandstone. Beneath this there is a drab colored sandstone 12 feet thick. Its shade of color and fineness of grain recommend it, but the extent of the supply is still unknown. The dip of the ledge is to the northwest.

The principal quarry at Orange mountain, in Essex county, produces stone for ordinary building purposes, used in Orange and vicinity. Among the buildings in which it may be seen are the Central Presbyterian church, the addition to Grace Protestant Episcopal church, South Orange Presbyterian church, and the residence of Davis Collamer, at Orange, and that of Kenyon Cox, at Millburn. The quarry is in the eastern face of Orange or Watching mountain, and about 250 feet higher than Orange. An excellent Telford road within 250 yards of the quarry leads to Orange and Newark. There are in all 14 feet of workable beds, one of which is 6 feet in thickness. There is considerable thickness of stripping, which consists of reddish shaly beds. This stone presents a pleasing appearance when dressed, either ax-hammered or bush-hammered, and is readily dressed. Like all the stone of Essex county, it hardens on exposure. The working advances in the direction of the dip; hence there is no advantage of gravity in getting blocks from the beds. There is a fault running north and south through the quarry, but the dislocation does not appear to be great. The plane of the fault dips about 85° to the east. The rock surfaces are coated with yellowish earth, and in places the rock is crumbling, so that there is no workable or marketable stone for a distance of from 1 foot to 3 feet from the fault plane.

There is a quarry at West Orange, Essex county, which produces a rather fine grained brownstone, used for buildings and trimmings, chiefly in New York and Orange. This quarry is in the valley between the first and the

second Watchung mountain ranges and near the summit of the second range. It occupies the same relativ position as the well-known Little Falls quarry. The stripping is not heavy, so that the aggregate thickness of work able beds is about 40 feet, but this does not include all, as there is said to be good stone at the bottom. The stone is heavy-bedded, and a set of regular and true joints extends through the ledge which facilitates the work of quarrying. The stone when quarried is easily dressed, and can be carved into any desired forms. It hardens by exposure. At present there is the disadvantage of having to move the stone by team a distance of from 2 to 4 miles before reaching railroad or canal. Among the most important buildings in the construction of which the stone from this quarry was used are the Presbyterian church at Caldwell, chapel of Grace Protestant Episcopal church at Orange, Reformed church at East Orange, Niles' mansion, Bloomfield, and a house at the quarry. Much of the stone was used in the construction of college buildings at Garden City, Long Island. During 1880 nearly all the material quarried, including a common rough stone, was marketed, the rough stone being used chiefly for walls at Garden City.

The gray feldspathic sandstone of the Palisade mountain is found in a crumbling condition on the east face of the Palisades and near the river, but not there suitable for building. At Englewood and Fenaly, in Bergen county, it is found so abundant in loose masses that this source has furnished stone for many elegant country houses and public structures; but no quarry in the rock *in situ* has as yet been opened.

At Paterson (in the western suburbs) a light colored buff stone has been quarried to some extent. The pleasing shade of color and its ease in working give it a local use.

The principal quarry near Paterson is in the eastern face of First mountain. The average stripping has been 15 feet thick, largely a red shale and sandstone with trap-rock debris fallen from cliffs above. The working has reached the trap rock wall, and now must be carried laterally or the trap-rock must be undermined. The rock face presents a vertical section, the divisions of which are approximately as follows:

	Feet.
1. Trap-rock	80
2. Red-shale rock	8
3. Red sandstone of varying thickness	15
4. Sandstone and shale irregularly alternating	10
5. Sandstone in two thick beds with shale intervening in places	20
6. Shale	1½
7. Grayish sandstone of the best quality for building purposes	15

The stone most used comes from Nos. 5 and 7 of this section. The quarry has advantages in location, giving a great thickness of strata above all drainage, and being situated, as it were, on the bank of the Morris canal. There are also three railroad stations within one mile. The principal markets are Paterson and Hackensack. Some is shipped to Newark and to Jersey City. The character of this material as to durability may be observed in the Passaic County jail building, and in many other buildings in Paterson and Hackensack. The principal drawback is the heavy stripping in the trap cliff; this might be thrown down and the stone utilized for roads. Professor Smock, of the New Jersey geological survey, thinks the stone under the trap-rock will probably be found more solid and in thick workable beds. (*a*)

In Washington valley, and at Martinsville, in Somerset county, there are quarries in the lighter-colored stones which look well in buildings. At the principal quarry at Martinsville the stripping at the north end is 21 feet thick, and consists mostly of red-shale earth at the top and red sandstone below. Some of the beds in the stripping furnish stone suitable for foundations. At the opposite end of the quarry the stripping has ranged from 10 to 30 feet. The total thickness of the courses now worked is about 20 feet, 11 feet of which is a light-colored freestone. At the bottom of the quarry a greenish shale sets in. The dip of the strata is 10° north-northeast. Most of the stones taken out are from 1 foot to 2 feet in thickness, but blocks 3 feet thick and 12 feet square may be obtained. The stone is readily sawed and dressed; gang-saws cut about 1 inch deep per hour in it. The light-colored stone is sawed into shape for caps, window sills, lintels, water-tables, etc. The principal markets for the stone from this quarry are Boundbrook, Somerville, Plainfield, Brooklyn, and neighboring places. Among the buildings in the construction of which it was used are those in Prospect park, Brooklyn, and a hotel in Martinsville. In old buildings where this stone has been used it proves to be durable.

At New Brunswick and along the Raritan River valley the stone is too shaly and does not weather well. The quarries are not now worked.

The Delaware River quarries supply a large quantity of stone to Trenton, Lambertville, Bordentown, Burlington, Philadelphia, and Camden. This stone varies somewhat in the different quarries. It is conglomeratic in the Prallsville quarries and in some of the beds at Greensburg. The best stone is of a reddish-gray shade, and contains a little feldspar associated with the quartz. The stone is easily dressed, and is used for both ornamental and common building work. Much of the Stockton-Prallsville stone has been used in the construction of heavy bridge work on the lines of the Pennsylvania Railroad company. The stone on this side of the state appears to be a little more open and porous than that of the Little Falls and Belleville quarries, and it favors the growth of a green fungus (?) in dark and shaded outside localities.

(*a*) *Geology of New Jersey*, 1868, p. 506.

There are four important quarries at Greensburg, and the stones from all of them are known in the market as "Trenton brownstone" or as freestone. The quarries are about four miles from Trenton, on the bank of the feeder of the Delaware and Raritan canal, and near the line of the Belvidere Delaware railroad; the Delaware and Boundbrook railroad crosses the Delaware river within a mile of the quarries. The general direction of the dip is north-northwest to an angle of about 10°. Some of the stripping consists of a friable and coarse-grained stone made up of a mixture of quartz and feldspar, with some red shale rock in places. The workable beds are from 12 to 15 feet in total thickness. These beds are usually separated by from 3 to 4 feet of red shale beds. The total thickness of merchantable stone is in some places 35 feet. The proximity of these quarries to both canal and railroad, their easy drainage, comparatively light stripping, and the thick beds of workable stone, are very considerable advantages. Its durability and the ease with which it is dressed create a large demand for this stone; the sale of the dirt and rotten rock of the stripping at a compensation sufficient to pay for removing it is another considerable advantage. The Trenton brownstone or freestone is most largely used in Trenton, and nearly all of the stone buildings are of this material; it is quite largely used in Philadelphia also, and a little is used in the towns along the Delaware river from Lambertville to Philadelphia. The following are some of the principal buildings in the construction of which the Trenton brownstone was used: House of Correction at Holmesburg, Pennsylvania; Catholic church, third and Reed streets; the Episcopal church, Nineteenth and Wallace streets; Presbyterian church, Twenty-first and Walnut streets; Presbyterian church, Twenty-second and Bainbridge streets; schoolhouse, Sixth and Coates streets, all at Philadelphia, Pennsylvania; the library building at Princeton, New Jersey; Saint Mary's church at Warren and Bank streets; and the residences of Hon. A. G. Ritchie, Rev. R. S. Manning, S. Prior, and others, at Trenton, New Jersey. For the composition of these stones see *Geology of New Jersey*, 1868, pp. 515, 516.

FLAGGING STONE.

At two localities, Woodsville, Mercer county, and Milford, Hunterdon county, flagging stone is obtained. There are several distinct openings near Milford. The quarries at Milford are all within two miles of the Milford Railroad depot, and are in the dark blue fine-grained sandstone of the Triassic formation near its junction with the gneissic rocks of the Archæan age. A full description of these localities may be found in the *Geology of New Jersey*, 1868, pp. 521, 522. The quarries are at present worked only for local markets along the Delaware river from Easton to Lambertville. The beds are generally quite thin, and most of the stone splits nicely, giving a smooth surface suitable for floors or sidewalks. The maximum thickness of flag-stone produced here is 4 inches; thicker layers are used for building purposes. The dip of the beds is 20° N., 40° W. A fine dividing plane or joint traverses the stone in a direction N. 75° E.; another runs N. 15° W. Impressions of stems, fragments of coal, and some supposed foot-prints have been found in this locality. The following is an analysis of this flag-stone made for the New Jersey geological survey:

	Per cent.
Sand and silicic acid	79.25
Protoxide of iron	3.78
Alumina	7.49
Lime	1.86
Magnesia	Trace
Potash	0.50
Soda	0.62
Sulphuric acid	1.39
Carbonic acid	1.46
Water	2.76
Moisture	0.40
Total	99.51

The principal quarry at Woodville is in a dark-colored, fine-grained shale of the Triassic age. The surface layers are shale; the beds below are a fine, bluish, slate-like rock, which, however, is properly classified with the sandstones. The dip of the strata is 20° N., 4° W., very irregularly bedded in layers varying in thickness from very thin flagging to those 16 inches thick. The excavation in the quarry is 40 feet deep at the deepest point. Stripping is easy and drainage natural, but the stone has to compete with the Hudson River blue-stone at Trenton and on the railroad lines; as better prices are obtained in the immediate neighborhood than at Trenton, the local demands regulate working. The fineness of grain and smooth surface of this stone make it desirable for flagging; although a slate-like rock, the cleavage is not of such a nature as to permit it to be used as roofing material. Flag stone of inferior quality is obtained at Princeton also. Martinsville quarry affords some stone suitable for flagging. In all of these places the stone is chiefly a fine-grained, slate-like rock, and generally of slate color. One of the quarries at Princeton produces what is called by Professor Smock a "blue, indurated, argillaceous sandstone", although, according to the classification adopted in this report, it is put with the slates. It is used for ordinary building purposes in Princeton.

Another quarry produces a grayish sandstone used to a limited extent for building purposes at various places along the Delaware and Raritan canal, and was used to some extent in the construction of the Princeton College buildings.

TRAP-ROCKS.

The trap-rocks included in the sandstones of the Triassic in New Jersey are quarried extensively, their principal use being for paving. The stone splits readily into blocks of specification sizes for street paving, and is hard, wearing well. For such use the oblong-shaped blocks are found to be quite as good as granite, and their employment is increasing in New York and in cities of the state. The quarries for paving blocks are confined mostly to the east bluff of the Palisade Mountain range, or Bergen hill, and to Goat hill, near Lambertville, in Hunterdon county. For building, the trap rock has been used in Jersey City and in Orange, but not to any great extent, although for large structures it is well adapted and looks finely. Trap-rock is also used largely for ballasting railroad beds and for Telford roads.

REFERENCES.—*Sandstone.*—(Analysis.) See *Geology of New Jersey*, 1868, pp. 215, 218. Trap-rock: *An. Rept. N. J.*, 1873, pp. 113, 114; *ibid.*, 1879, pp. 25, 26; *ibid.*, 1881, pp. 60, 63.

The principal quarry in the Triassic trap, or diabase, is at Bergen hill, Hudson county. It is used for paving blocks chiefly in New York, Jersey City, Hoboken, and Newark. The trap-rock quarries at this place are confined to the eastern brow of the hill and to the summit of the range. They extend at intervals from Montgomery street, Jersey City, to the Bergen County line, a distance of 7 miles. These quarries are very small; they are opened on the brow of the hill where streets are to be cut through, or on knobs such as mount Pleasant, near the track of the Pennsylvania railroad, which is to be taken down to a much lower level. Others are so located as to get stone most easily and of quality suitable for use. The excavations are not sunk into the rock, but are simply extended into the ledge as it projects from the hill. There is but little stripping, cap-rock, or waste of any kind; nearly all of the rock is used. All the quarries are worked on leases, and a common practice is for a gang of three or four men to work together. The only capital is the value of tools and powder, averaging probably less than $100 to each quarry. The specification paving blocks are cut 8 by 16 inches (or by 12) by 4 inches; the square blocks are 5 or 6 by 7 inches. The former are cut with some regard to dimensions, but the square blocks are cut with much variation, some having nearly twice the cubical contents of others. There is much variation in the stones of different localities, and some cuts much more readily than others, and with less waste. The spalls are used for Telford-road making. Black powder is employed to break off large masses, which are broken up by hand-sledges, and the blocks are split out by hammers. The blocks are carted direct from the quarries to streets to be paved in New York or Jersey City. The specification block is growing in favor, and the use of trap-rock as a paving stone is increasing very rapidly. Against the square blocks there seems to be a serious objection—that its surface grows smooth very soon and is slippery; but against the oblong blocks the objection does not exist.

The location of these quarries is above all water, with natural drainage, with no stripping to be removed, and they are often worked for the double purpose of removing the stone in the grading of streets and for paving stone. As a building stone this trap-rock has been used with good results in Saint Patrick's church in Jersey City, and in the Hudson County court-house, besides other edifices both public and private. It is also used in retaining-walls.

The late Dr. George W. Hawes said of this Triassic diabase or trap:

From a specimen of the normal rock from Jersey City the feldspar was separated and was analyzed by Dr. Howe, and proved to be complex, a circumstance not indicated by the microscopic examination. The process of separation by means of the specific gravity necessitated the presence of what may be called "middlings", which were not sufficiently dwelt upon, and which may be supposed to have modified somewhat the composition of the parts. One part was a little more siliceous than labradorite, and the other analysis gave the formula of andesite. The second feldspar may be assumed to be a little more acid than the analysis.

The complexity of the feldspathic element being demonstrated in this case, we may, if we choose, by a calculation, indicate the percentage of the feldspar in the rock, if the composition of the pyroxene is known. The pyroxene of West rock has been analyzed, and if this rock is selected as typical we obtain:

	Per cent.
Anorthite	15.52
Albite	22.16
Potash feldspar	2.32
Pyroxene	54.47
Titanic iron	2.68
Magnetite	1.76
Apatite	0.32
Total	99.23

Thus the percentage of total feldspar is shown, but it is not intended in any degree to suggest that anorthite, albite, and potash-feldspar are present in these or any proportions, but a calculation is only possible when the extreme species are considered; and, these molecular relations being known, in the words of the article "it becomes easy to see how extremely diversified the feldspathic elements may be in rocks of this nature. The molecules may arrange themselves in very diversified ways, while the rocks remain identical in composition".

This method of calculating the amount of feldspar has been very often used.. West rock, according to the calculation, includes just 40 per cent. of feldspar, which contains the elements that might form three species or be combined in one. In the Jersey City rock the feldspathic molecules have combined to form labradorite and andesite. In a little dike which intersects West rock, forming a bit of its western face, and identical in composition with all the rocks of this remarkably uniform system, anorthite has formed in small amount, which does not necessitate a more basic rock, since a simple arrangement of the remaining feldspathic molecules into other species could compensate for this.

It is known that Jersey City trap consists of pyroxene, two feldspars of intermediate composition, titanic iron, magnetite, and some minutely microscopic ingredients; and the occurrence of anorthite in rocks of like composition that may be supposed to have cooled under different conditions indicates that constancy of composition as regards the species of feldspar is not to be expected.

LATER FORMATIONS.

BROWN SANDSTONE AND CONGLOMERATE.—This is the only building stone found in the southern half of the state. It is a cemented sand or gravel, and the cementing material is iron oxide. It is not confined to any particular geological horizon, but occurs from the lower beds of the Cretaceous age to the latest drift, although more common in the outcrop of the red-sand bed and the drift gravel of the southeastern part of the state. In the absence of any other stone it is useful and is largely used for foundations and cellar walls. The quarries are generally small pits or shallow openings, and the stones occur in beds of varying thickness, lying upon earthy strata or beds, and covered by sand, or sand and gravel or earthy materials. In a few instances buildings have been constructed of this stone.

REFERENCES.—*Geology of New Jersey*, 1868, pp. 516, 517, and *Ann. Rept.*, 1881, pp. 66, 68.

At Egg Harbor city, Atlantic county, a quarry of this stone is located on rocks of Cretaceous age. A description of this quarry and the material produced by it will illustrate what is done in southern New Jersey in these quarries of brown sandstone.

The stone from the Egg Harbor quarry is durable, as it hardens on exposure, but it is not adapted to nice work, and hence its use is limited to the construction of wine vaults at Egg Harbor city, foundations, cellar walls, and occasionally bridge abutments and a few buildings: one is a Protestant Episcopal church at Eatontown, Monmouth county, built of stone from the vicinity; another is the West Jersey academy at Bridgeton, built of stone quarried near the town. Some of this material was used in the construction of the large dam at May's Landing. Among the more important of the numerous quarries in this stone are the following: near Eatontown, Monmouth county; Stonehill, Atlantic township, Monmouth county; Arney's mount, Burlington county; near Wareton, Ocean county; Bridgeton, Cumberland county; Egg Harbor city, Atlantic county; May's Landing, Atlantic county.

PENNSYLVANIA.

[Compiled mainly from notes of members of the Second Geological Survey, etc.]

BUILDING-STONE RESOURCES.

The ranges of the Appalachian mountains passing in a general direction northeast and southwest through the central and eastern parts of the state are the most marked feature in the geographical structure; and, speaking very generally, the exposures of the different geological formations, especially in the mountain regions of the state, are in the form of bands, of greater or less width, having the same direction as the mountains.

The oldest rocks in the state are the Archæan, in the southeastern corner; and going west and northwest newer rocks appear in consecutive order, with the following exceptions:

There is a belt of Mesozoic red sandstone passing through the southwestern corner of the state, lying unconformably on and bounded by rocks of Archæan and Lower Silurian age. This is the latest formation found within the limits of the state. It is described very fully in Vol. II, *First Geological Survey of Pennsylvania*, by Professor Henry D. Rogers.

The next important exception is the anthracite-coal fields of eastern Pennsylvania. These are comparatively narrow belts, the exposures of which are bounded by sub-Carboniferous and Devonian rocks. In the reports of the geological survey of Pennsylvania the preservation of these isolated Carboniferous strata is ascribed to the fact that there is a marked depression of the surface in this section of the state, placing the rocks much lower than those of the same age in other mountain regions.

There are small, separate areas of the Lower Silurian limestone, sometimes called Siluro-Cambrian, by Lesley, in the second Pennsylvania survey, and called by Rogers the Auroral limestone.

Among the most important in their resources of building stone, beginning at the southeast, are the Archæan rocks before mentioned, which furnish gneisses in the neighborhood of Philadelphia and Chester county; serpentines in Chester county, and slates, for roofing purposes, in York county.

The Mesozoic or Triassic belt before mentioned furnishes a brown sandstone at various localities, which material is of the same age and bears a general resemblance to the brownstone of the Connecticut valley, and there is a belt of this age in Nova Scotia furnishing sandstone of superior quality for building purposes, but it does not bear as much resemblance to the Connecticut stone as does the material of the Triassic formation quarried in Pennsylvania.

There are dikes of trap-rock cutting this Mesozoic belt at various points. A microscopic examination shows it to be a diabase, and it furnishes a very hard and practically indestructible building material, but from its hardness it is difficult to work and is dull and somber in appearance. There are quarries in these dikes at Collins station, near Falmouth, in Lancaster county, and near York Haven, in York county. Surface bowlders of the material are taken up for purposes of construction on and near Cemetery ridge, Gettysburg, Adams county. The trap at this place lies a short distance south of the present southern boundary of the Mesozoic sandstone, but there is little doubt that it is contemporary with the trap dikes which cut the Mesozoic sandstone at various places. The most

important quarries at present are at Hummelstown, and the material is also quarried at Yardleyville, Lumberton, and Newtown, Bucks county, to a slight extent near Reading, in Berks county, and at York Haven, in York county.

The Lower Silurian or Auroral limestone before mentioned, which covers quite a large area in Cumberland or Lebanon valley (the Shenandoah valley of Virginia), furnishes by far the largest part of the limestone quarried in the state. The isolated bodies of this limestone in Montgomery, Chester, Lancaster, and York counties, lying southeast of the main body of the strata, furnish, in Montgomery county, the "Pennsylvania marble"; but in the other counties mentioned they furnish a limestone similar to that to be found almost everywhere in the Cumberland valley.

Strata of Hudson River age, lying immediately upon the Lower Silurian limestone, in Northampton and Lehigh counties, furnish roofing slates which are extensively quarried, the trade in which is rapidly increasing year by year.

Northwestward of the Lower Silurian limestones there is quite an extended area of Devonian strata, and on these there are ledges of Catskill sandstone in Pike county and vicinity that are much quarried for flags. The material is of the same structure and character as the North River blue-stone so extensively quarried in Ulster county, New York, for flags, and is scarcely distinguishable from it: it is marketed with the North River blue-stone and bears the same name.

The strata in this region are usually thin and evenly bedded shales and sandstones, hard, fine, and compact in texture, and particularly well adapted to paving purposes. In Wyoming county, in the vicinity of Meshoppen, there are quarries located on Devonian strata of the Chemung horizon, and the material is a very superior, fine-grained, compact, light gray or bluish sandstone, well adapted to the better class of construction, which is rapidly coming into use in New York and other eastern cities. Although the courses here are usually sufficiently thick to furnish material suitable for massive construction, much of it is thinly-bedded and is extensively quarried for sidewalk paving.

There are flag quarries also in Susquehanna and Tioga counties, and numerous other quarries are distributed over the country covered by these rocks, but the localities mentioned are the principal ones thus far where they have been quarried for purposes of construction.

There are numerous quarries of sub-Carboniferous flag-stone, probably of Chemung age, and certainly belonging to the Venango Oil group, along the high divide overlooking lake Erie, in Erie county.

There is one important quarry of umbral or mountain limestone (a division of the sub-Carboniferous in Pennsylvania), near Connellsville, Fayette county, quarried for street paving, and marketed thus far chiefly in Pittsburgh.

The Carboniferous area in the western portion of the state furnishes but little excepting coarse sandstone and conglomerates, which have been extensively used for local construction, but are usually not of such a quality as to justify their being shipped to distant points. There are, however, a few quarries producing material of such quality that they are used to some extent for building purposes in neighboring towns and cities; among these may be mentioned a quarry at Gallitzen, on the Pennsylvania railroad west of Altoona, and the quarries at Baden, Homewood, and Beaver Falls, in Beaver county. In Washington and Greene counties there are ledges of Coal-Measure sandstone sufficiently durable and of good quality for ordinary uses, though they have been as yet but little used.

ARCHEAN ROCKS

The southern gneissic district described in the geological reports of Pennsylvania, as ranging from the Delaware at Trenton to the Susquehanna, south of the state line, and lying south of the limestone valley of Montgomery and Chester counties, is the district in which are located nearly all the quarries of gneiss in the state; and those furnishing most of the material are in the vicinity of Philadelphia. This rock is here extensively used for foundations, walls, docks, paving blocks, curbs, and rubble work. It is for the most part a hornblende gneiss; in some of the quarries it is a muscovite gneiss, and there is a quarry at Frankfort, in the Twenty-third ward, Philadelphia, producing material which may properly be called a biotite granite.

There are quarries of hornblende gneiss at Rittenhousetown, Twenty-first ward, Germantown, Twenty-second ward, and Jenkinstown, Montgomery county. This material is gray in color, varying from light to dark and from fine to coarse in texture. It usually lies in sheets sometimes horizontal, sometimes vertical, though they are found inclined at every angle. It usually splits very regularly in the direction of the lamination, and is conveniently wrought into regular blocks for the purposes for which it is used. Some varieties of the gneiss are subject to decay from the decomposition of the feldspar, by means of which the rock is disintegrated.

Near Chester, Delaware county, the gneiss is very extensively quarried for the same purposes for which it is quarried within the limits of Philadelphia. The ingredients of which it is composed vary within certain limits, so that, according to the system of nomenclature used in this report, some of it is called a biotite gneiss, some biotite-muscovite gneiss, and some muscovite biotite gneiss. The proximity of the quarries to the Delaware river affords ready means of transportation to Philadelphia and other cities and towns bordering on that river. The following

list includes some of the important buildings in which this stone has been used, chiefly for foundations: The Cooper hospital, Camden, New Jersey; church in Chester, Pennsylvania; Catholic church, Third and Reed streets, and Presbyterian church, Nineteenth and Green streets, Philadelphia; Saint Charles Bartholemew church, near Philadelphia; railroad station buildings, Overbrook; fort Delaware, built largely of this rock; various light houses along the Delaware river; and the following structures in Philadelphia: Chestnut Street bridge (partly); Market Street Bridge abutments and piers; Junction Railroad bridge; Manayunk bridge; Penrose Ferry bridge; foundations of Market Street gas-works; foundations of Girard college; Fairmount water works; Blockley alms house; the old Naval Asylum and the Arsenal buildings. Also Swarthmore college, Delaware county.

In many private residences in Philadelphia and vicinity the walls are built of rough blocks of this stone firmly cemented together and presenting a very pleasing appearance.

As before stated the principal quarries in the Mesozoic trap are at Collins station, Lancaster county, and some in a like on the opposite side of the Susquehanna river near York Haven, York county. The following description of the York Haven trap will give a general idea of these dikes wherever exposed. The face of this particular quarry is about 70 feet in height, but the material extends to an unknown depth. It lies in huge natural blocks sometimes weighing hundreds of tons, and having curved outlines giving them a sort of oval shape. Smaller blocks of various shapes are wedged in between the larger ones, and sometimes regular parallel sheets are seen lying together, usually near the top of the mass. The stone is reduced to proper shape by drilling rows of holes about three inches in depth and using plug and feather. It splits well in two directions. Stone from this quarry is used only by the Northern Central railroad in the construction of bridges, culverts, etc., and its indestructible nature and the fact that it may be quarried in regular massive blocks of any desired size make it a very desirable material to be used for these purposes.

At the Kellar quarry, Collins station, the stone is more extensively quarried than at any other place in the state, and is used for curbing, steps, base courses, cemetery work, caps, sills, columns, etc. The stone is used in the foundation of the new Harrisburg post-office, the superstructure of which is of the Richmond, Virginia, and Manchester, New Hampshire, granites; and the soldiers' monument at Harrisburg is a rectangular obelisk wholly built of this material.

There is much information concerning the geographical limits, geology, and character of material of these trap dikes in Report C C C, *Second Geological Survey of Pennsylvania.*

The material of the trap bowlders quarried near Gettysburg, and before referred to, is a diabase exactly similar to the stone in these dikes wherever they appear; but in this immediate vicinity there is an unusually large number of surface bowlders, and they have thus far supplied all the stone quarried here, there having been no necessity to operate on the dikes in place. The bowlders are particularly numerous and of large size in the vicinity of Vincent's Spur, Round Top, and Little Round Top, prominences of Cemetery ridge, along which the army of the Potomac was posted during the battle of Gettysburg. The places mentioned are all in close contiguity; and Devil's Den, where there is also a fine exposure of these trap-rocks, lies also at the base of Round Top. The bowlders are also to be found at Culp's hill, the northern extremity of Cemetery ridge. The stone is obtained in regular blocks by plug and feather, in the same manner as at Collins station and York Haven, and is used to a considerable extent for steps, caps, curbs, bases, and cemetery work in general. The stone is used in the Gettysburg national cemetery as head-stones. It may be seen in use in nearly all the towns within a radius of 50 or 60 miles of Gettysburg, and is known as Gettysburg granite.

SERPENTINE AND SOAP-STONE.

Serpentine is becoming more and more popular as a building material. The Chester County stone has attracted much attention in many quarters. Quite a number of important buildings have been constructed of it in Philadelphia, Washington, and Chicago. The stone is apparently very durable, and buildings in the neighborhood of West Chester, which have been erected over one hundred years, are fresh and maintain their attractive color unchanged. The stone is easily worked, and it is claimed that it can be furnished at a smaller cost than any other stone at the quarry.

Professor Henry D. Rogers, in Vol. I, *Geological Survey of Pennsylvania*, describes a number of belts and outcrops of serpentine in the southeastern corner of Pennsylvania south of the limestone valley of Montgomery and Chester counties. The first, or the most northwesterly, serpentine and steatite range is near the Schuylkill river in the southern edge of Montgomery county, and is the most eastern zone of the magnesian rocks in southern Pennsylvania. It is a long, straight, narrow line of outcrop of steatite or serpentine crossing the Wissahickon creek and the Schuylkill river. The steatite in this belt predominates, serpentine being usually dispersed through it in lumps. The steatite, where sufficiently free from the serpentine, was formerly quarried for the lining of stoves, fire-places, and furnaces; the principal market being the city of Philadelphia. It is also sawed into slabs of various thicknesses and used for mantels, stoves, sinks, etc. The débris is sometimes ground into a flour and used for foundery facings, lubricating purposes, roofing material, in paint manufacture, and for various other purposes.

Toward the end of the last century, before the introduction of the Montgomery County marble, this easily-quarried material was used for street-door steps in Philadelphia, but its unequal hardness, owing to the dispersion

of imperfectly-crystallized lumps of serpentine, caused it to wear unevenly and to soon present a rough appearance; and Professor Rogers notices the fact that in some old and much-worn door-sills of this rock the knots of the serpentine mineral project above the steatite like hob-nails in a plank. The fifth serpentine tract, or that of the West Chester barrens, is the one which has been quarried most for building purposes. The rock here is of a grayish-green color, massive, medium fine and uniform in texture, and has been extensively used for buildings, principally as ashlar in walls. The principal markets are Philadelphia, Baltimore, New York, and Washington, and it has been shipped as far west as Chicago.

Among the principal constructions of this stone are the Girls' Normal School building, Seventeenth and Spring Garden streets, Academy of Natural Sciences, Philadelphia; Pennsylvania University buildings, West Philadelphia; the court-house, Wilmington, Delaware, and 20 large churches, a number of school buildings, and several hundred private residences in Philadelphia, and more particularly in West Philadelphia. A portion of the material is sawed at the quarry. Several old farm-houses in the neighborhood built of this stone more than a century ago are reported, two having been erected in 1730; and the color of the stone is as perfect as when first quarried. A number of columns 6 feet long and 12 inches in diameter were furnished from this quarry for the university of Pennsylvania. This is about the longest that can be obtained, but it is not difficult to find good sound pieces 4 feet long and 6 or 8 inches thick. The broken and jointed character of the rock renders it impossible to obtain large blocks, hence its chief use thus far has been as ashlar in the walls of buildings. This stone can be readily carved, but cannot be sawed into very thin slabs. Although it has only been introduced to the public in the past ten years, it has been very extensively used by architects and builders, especially in Philadelphia. The quality of the stone both as to color and texture is more uniform in every respect than it was when the quarries were first worked, and the supply appears to be practically inexhaustible.

Near Rising Sun, Maryland, in the southern edge of Chester county, Pennsylvania, there is a serpentine tract upon which is located a quarry, formerly extensively worked, but which was idle during 1880. There are also one or two other quarries on this tract in the same locality; and there is a quarry of serpentine near Media, Delaware county, which, however, was not operated during 1880. Some of the stone for the building of the Pennsylvania university, West Philadelphia, was obtained at the Media quarry, and some at the quarries near Rising Sun, Maryland.

LIMESTONE.

Lower Silurian.—At the Bushkill quarries, Easton, Northampton county, the lowermost portion of the great Lower Silurian limestone of Pennsylvania, known as the Calciferous, is quarried for ordinary building purposes, and has quite an extensive local use for base courses and curbs, and is also burned for lime. An analysis of the stone shows it to be highly magnesian; in fact it may properly be called a dolomite. Graphite and protoxide of iron are found in specimens of the stone. The limestone in and around Easton is in comparatively even beds, and good stone of proper shape for building purposes can readily be obtained, though the stratum inclines sometimes at high angles. The base of the court-house and many other buildings in Easton are of this limestone, chiefly from the Bushkill quarries.

Montgomery County marble.—The Montgomery County marble, so extensively used in Philadelphia, is quarried from an isolated belt of the great Magnesian or Auroral limestone of Lower Silurian age. Professor H. D. Rogers, in the *Report of the First Geological Survey of Pennsylvania*, describes the geographical limits and geology of this limestone belt substantially as follows: It is the bed of a long, narrow valley in Chester and Montgomery counties; the ridges bounding the valley consist of the primal slates and primal white sandstone. The whole is a narrow, synclinal basin, with strata closely folded together, those of both sides of the trough dipping with much regularity to the south-southeast at an angle ranging between 60° and 70°. All the strata here are greatly altered by diffused igneous action. The belt of limestone itself, which forms the great valley, extends through the western half of Montgomery county, southwestward through Chester county, and Sadsbury and Bart townships, in Lancaster county. The general geological structure of this populous and rich limestone belt, is extremely simple. Measured from one extremity to the other, the limestone, coincident very nearly with the bed of the valley, has a total length of about 58 miles; its eastern end being just north of Abington, in Montgomery county, and its western end is at the source of Big Beaver creek, in Lancaster county. In form it resembles very much a long, slender fish. The general structure of this first main belt of the Auroral limestone is that of a long and slender basin or a synclinal trough, the southern side of which is much steeper than the northern. The strata of the southern side of the valley dip perpendicularly, often a little overturned into a steep south dip, but sometimes incline steeply in the normal direction or northward. It is only toward the western extremity, where the whole trough grows shallow as it rises up and thins away, that the north dip ceases to be steep. The strata of the north side of the valley, or from the synclinal axis northward, dip at an average inclination of about 45° southward, or more strictly, south 20° east: this inclination, however, is not absolutely constant. Throughout this limestone basin the southern steeply-upturned outcrop exhibits a far higher degree of metamorphism by heat than the northern, and this alteration appears greater where the strata approach most nearly a vertical position, and is greater still where they are inverted: that is to say, between Wissahickon and Brandywine creeks. It is chiefly within these limits that the elsewhere bluish and yellowish limestone is in a condition of crystalline and granular marble, white shaded

or mottled from the dispersing and segregating action of a high temperature upon its changeable ingredients. All the marble quarries hitherto opened are included in this steeply upturned or overturned outcrop, the best of this lying within half a mile of the southern edge of the formation, or of some sharp, inverted anticlinal like that of the Conoquenessing ridge. Throughout the northern half of the basin, especially where the limestone observes its usually very regular southward dip of seldom more than 45°, the rock is in the condition of a subcrystalline and earthy or purely sedimentary magnesian limestone, and its bedding is for the most part very uniform and rather thick. Its color is a pale greenish blue, except in neighborhoods like that on the Schuylkill, below Norristown, where a partial metamorphism has approached the northern border, and it is then very frequently a pale straw color and a pale bluish white; but the slate in which the very same beds exist, where they rise perpendicularly or with inversion to their southern outcrop, after passing the synclinal turn in the center of the basin, is very different from all this, and in striking contrast with the faintly crystalline and earthy limestone which is here a distinctly crystallized and often granular marble. Its color is changed to a brilliant white or to a mottling of purely white and dark blue from the presence of segregated or half-developed graphite, and the dispersed ferruginous matter is here in a state of minute, solitary crystals of sulphuret of iron disseminated through the body of the stone. Viewed edgewise a fresh exposure of the most altered limestone, such as is visible on the Schuylkill river, near Conshohocken, has the aspect of a blue and mottled marble streaked with films of talc and shivered by innumerable cleavage joints; but viewed facewise the layers and fragments have an aspect of a talcose or micaceous slate, so copious is the covering of talc and mica upon their surface.

The belt of marble in Montgomery county is about three-quarters of a mile wide, and it is in this county that the principal quarries on this belt are now operated. Marble Hall, in this county, is the easternmost point at which good marble is quarried, and the best of the material lies between this point and the Schuylkill river nearly to the Chester County line.

A mile from Spring Mill station on the Germantown and Norristown railroad the marble is quarried for buildings, cemetery work, and furnace flux, and shipped to Philadelphia, Lancaster, and other places in Pennsylvania, and to Washington, District of Columbia. The stone here varies in texture from coarse to fine, is semi-crystalline, light blue in color, with signs of irregular stratification, unevenly bedded, and in medium to thick layers. Blocks of 500 cubic feet might be moved in this quarry. Steam-drills are used in quarrying, and powder, and to some extent dynamite, in blasting. The production here during 1880 is said to have been less than the average.

Near Bridgeport, Montgomery county, the marble is quarried for ordinary building purposes, and shipped chiefly to Philadelphia and throughout Pennsylvania. It is here of a light blue, fine, semi-crystalline texture, with signs of irregular stratification, evenly bedded, and in medium to thick courses. It was used in the construction of the following buildings in Philadelphia: Girard college, United States custom-house, Merchants' exchange, and the passenger depot of the Pennsylvania railroad, at Broad and Filbert streets.

Near King of Prussia station, on the Chester Valley railroad, in Montgomery county, marble is quarried for ordinary building purposes, and shipped to Philadelphia, Baltimore, and throughout Pennsylvania. It is blue, has a fine, semi-crystalline texture, signs of irregular stratification, is rather unevenly bedded, and in thick courses. Plate V represents the polished surface of a specimen of this marble. It was used in the construction of Girard college, the new city building at Broad and Market streets, the old post-office and numerous churches in Philadelphia, and the court-house at Norristown.

At Henderson station, Montgomery county, similar marble is quarried for ordinary building purposes, and shipped to the cities of Philadelphia, Baltimore, and Washington. This marble was used in the construction of the Law Library building in Philadelphia.

At East and West Conshohocken, in Montgomery county, on opposite sides of the Schuylkill river, the ledge is quarried, the product being commonly known as limestone. It is gray, with a rather coarse, semi-crystalline texture, irregularly stratified, and comparatively even bedded in layers of varying thickness up to 2 feet; it is but little jointed, and its difference in texture and structure from the material in the marble quarries of this district is apparently due to less disturbance of the strata. The principal use of the stone at present is for foundations and bridge abutments. The stone-work of the Philadelphia and Reading Railroad bridge at the falls of the Schuylkill and that of the Girard Avenue and the Callowhill bridges, Philadelphia, is of this material. The following are some of the buildings the foundations of which were built of stone from the West Conshohocken quarries: The new city buildings, Broad and Market streets; Masonic temple, Broad and Filbert streets; Main Exhibition building, Memorial hall, Machinery hall, and Horticultural hall, in Fairmount park; Philadelphia Saving Fund building; Provident Life and Trust Company building, and the Union Insurance Company building; new grain elevator of the Philadelphia and Reading Railroad Company; South Street bridge; E. H. Fitler & Co.'s new buildings at Bridesburg; bridges on line of Philadelphia and Reading railroad, and on the connecting link of the Boundbrook line to New York.

Beside the limestone or marble of the Lower Silurian or Siluro-Cambrian belt of Montgomery county, there are quarries at various other points in Pennsylvania on this formation where the stone is quarried for ordinary building purposes, chiefly to supply local demands. There are quarries of this kind at Easton, as before mentioned, at Tuckerton and Reading, in Berks county, and in Lebanon county; near Harrisburg, Dauphin county; Leaman Place, Lancaster county; York, York county; and at Bridgeport, Shiremanstown, and Carlisle, Cumberland county.

There are also numerous other points where the material is quarried principally for lime, and where but little of the product is used for building purposes. At Tuckerton the stone is gray in color, massive, and the courses are even and thick. The stone is a calcareous dolomite. It lies in courses varying from about a foot at the top to 2 feet or more in thickness at the bottom of the quarry, and the total depth of stone quarried is about 50 feet, the inconvenience of drainage being the cause for not going deeper. The joints are from 3 to 20 feet apart. This quarry is operated by the Philadelphia and Reading railroad, chiefly to obtain stone for bridge construction and other railroad work. The inclination of the strata at this quarry is about 12° or 5°, and, contrary to the condition of the rock at other places near Reading, it is not much broken by joints, and hence is in a more favorable condition to be used for building purposes. Portions of the ledge of limestone not far distant from the Tuckerton quarry are upturned at a high angle, very much jointed and broken, and are quarried extensively for lime burning and furnace flux. The material the point where the Tuckerton quarry is located is a limestone, but is not of sufficient purity to be well adapted either for furnace flux or for lime burning, but the regularity of the strata and the substantial and durable character of the stone recommend it for building purposes. (*a*)

At Reading, a few miles south of the Tuckerton quarry, this limestone is worked only to a depth to which natural drainage is obtained—10 or 15 feet. Stone similar in character to that quarried extends downward to an unknown depth. In some sections of the quarries the ledge is a solid mass, and in others the division of the layers varies from 4 inches to 1 foot in thickness. The inclination of the strata is 45°. The stone is of a bluish color, with indistinct signs of stratification, fine in texture, and a qualitative analysis shows that it contains graphite, protoxide of iron, much lime, and considerable magnesia. It is scientifically a calcareous dolomite. This stone is well adapted to the purposes for which it is used in Reading and vicinity, such as cellar walls, foundations, curbstones, and for macadamizing streets and roads.

The Annville (Lebanon county) quarries of this formation produce limestone which is used for building, and for lime and furnace flux; the building stone and furnace flux are used chiefly at Lebanon, and considerable lime is sent to Wilmington, Delaware. The stone here is a blue-black color, irregularly stratified, fine and semi-crystalline in texture. The stone at this point contains less magnesia than that at most places in Pennsylvania where limestone of the same age is exposed. The magnesia is nearly always a prominent feature in the rock of this age in Pennsylvania, and the *Second Geological Survey* entitles it the magnesian limestone formation.

Four and a half miles southeast of Harrisburg, on the east side of the Susquehanna river, there is a quarry of this rock, producing material for building purposes, for lime, and for furnace flux. The stone here is a dark gray in color, fine, compact texture, is irregularly stratified, lies in even courses varying in thickness from a few inches to 2 feet or more, and is a magnesian limestone.

At Leaman Place station, Lancaster county, this limestone is quarried for building purposes, and is used chiefly in Philadelphia, Lancaster, Harrisburg, and on the line of the Pennsylvania railroad.

The abutments of the Conestoga bridge at Lancaster and those of the State Street bridge at Harrisburg are built of this stone. It is here dark gray in color, indistinctly stratified, and fine in texture; is a calcareous dolomite, containing graphite, some protoxide of iron, and sulphides of copper and iron. The courses are even and from 3 inches to 3 feet in thickness.

At Lancaster the stone is quarried for local use, chiefly for cellar walls and foundations. It is here blue-black in color, fine in texture, and with signs of indistinct stratification; contains a high percentage of magnesia, and is a dolomite. It contains graphite, protoxide of iron, little lime, and much magnesia. It lies in even beds, from a few inches to 2 or 3 feet in thickness, and the joints are usually from 3 to 20 or 30 feet apart. The walls of the Lancaster County prison are built of this stone. The height of the face of the quarries is about 20 feet. The strata are tilted up at an angle of about 45°, and a material of quality similar to that quarried might be obtained to an unknown depth, as is true at other quarries of the vicinity. The quarrymen find it convenient to go no deeper than the point at which natural drainage may be obtained. The rock in these quarries is not of a character to answer well for furnace flux, though the same ledge is quarried for that purpose a short distance away.

It may be observed here that throughout eastern Pennsylvania, where this Lower Silurian limestone outcrops in places where the rock was found in even, massive, thick, and little-jointed courses so as to be readily obtained in proper shape for building purposes, the material seems to contain too great a proportion of ingredients other than lime to answer well for furnace flux or lime burning; and, on the other hand, where the strata are much tilted and broken by joints so as not to be susceptible of being readily wrought into shape for building purposes, its composition is such as to make it well adapted to use for furnace flux and lime. In the Lancaster quarries, although the layers have an even surface, the stone breaks with an irregular fracture and is rather difficult to shape for other than the ruder purposes for which it is now used. Several old one-story houses constructed of this material are still standing in Lancaster, some of which were built a century ago. The only way in which the weather seems to affect this stone is to fade it to a lighter color, and this is due probably to the evaporation of the water, which process also has the effect of hardening it. This stone underlies a large area of Lancaster county and is extensively used by farmers, their barns and residences being often constructed of it. (*b*)

(*a*) Report M M, p. 304, *Second Geological Survey of Pennsylvania*.

(*b*) For analysis see Report M M, p. 304, *Second Geological Survey of Pennsylvania*: Silurio-Cambrian Limestone.

Near York, York county, the Lower Silurian limestone is quarried for the ruder building purposes, such as cellar walls, foundations, and bridge abutments, and to some extent for paving blocks. Nearly all the streets of York are macadamized with this stone, it being about the only material used for the purpose in the town and vicinity. There are, however, two varieties here, one used for building purposes and the other for burning and as a fertilizer. The variety which is used for building purposes is blue-black in color, fine, compact, and uniform in texture, with no signs of stratification, and contains a high enough percentage of magnesia to be called a calcareous dolomite. It contains graphite, which is doubtless a principal part of the coloring matter, little iron, much lime, and little magnesia. The courses are even, from 15 inches to 2½ feet in thickness, and almost horizontal, there being but little dip. The material is quarried with comparative ease in regular blocks for building purposes, and is used almost exclusively for cellar walls, foundations, bridge abutments, etc., the local demand being greater at present than the production.

The height of the face of the quarry is 20 feet, the material being quarried only to the depth at which the natural drainage is obtained. There is no exposure showing the actual thickness of the ledge. The stone which is burned for a fertilizer is white in color, fine and crystalline in texture, containing less magnesia than the variety used for building purposes; it also differs from it in the absence of graphite or other coloring matter, and contains a greater proportion of the carbonate of lime. The courses are uneven and irregular, being much jointed, and the natural blocks vary much in size and shape. The height of the face of the quarry is about 15 feet. It is noticeable that the dip of the strata in these quarries is from 15° to 20°, which constitutes another marked point of difference between the white and the blue black limestone quarried near York. In some places there are divisions into layers varying from 1 foot to 6 feet in thickness, but often the ledge is simply a broken and much jointed mass. There is always more or less metamorphism in portions of the ledge producing the white limestone, the material in some places being a kind of marble of a white and bluish mottled color. The rock when burned makes a superior quality of white lime, and would be a durable building stone, but rather too expensive, owing to its hardness and the difficulty of obtaining rectangular blocks. It has no regular cleavage and cannot be split into prismatic blocks. There has been apparently enough metamorphic action to partially destroy the stratification, but not enough to entirely convert the material into a crystalline marble. Nearly every farmer in the vicinity of York has an opening in his limestone and uses it for building purposes and for fertilizing fields. The stripping in the vicinity of York is usually a red clay of the Mesozoic or New Red Sandstone formation. (*a*)

At Bridgeport, on the opposite side of the Susquehanna at Harrisburg, this limestone is extensively quarried for foundations, furnace flux, railroad ballast, and fertilizers. It is here dark drab in color, fine, hard, compact, and in texture rather brittle; it is a dolomite containing graphite and some protoxide of iron. Analyses of specimens from 115 layers of the rock in these quarries are given in Report M M of the *Second Geological Survey of Pennsylvania*, which seem to show that alternate strata of limestone and dolomite make up the mass; that the dolomite layers carry the most insoluble materials, and that as a rule each layer is nearly homogeneous. Magnesia is present in greater or less quantities in all the layers. It is even and rather distinctly stratified; the bedding is moderately uneven, and varies from a few inches to 10 feet in thickness; the joints are from 6 to 20 or 30 feet apart; the strata dip at an angle of 30° or 35°, and the depth of the face of the quarries at present opened varies from 15 to 40 feet, the variation being due to prominences and depressions in the outcrop of the ledge. The railroad track running into the quarry is on the level at which the material is quarried. The bed of the Susquehanna river at Harrisburg is of this material. The upturned edges of the strata over which the waters pass may be seen from the bridges in the vicinity, as the river is shallow and the water quite clear. The limestone here is of such composition and character as not to be very soluble in water, so that it does not wear away rapidly under the action of the river, although the current is quite rapid. The abutments of the bridges are mainly constructed of this limestone. It is found most convenient not to quarry the material in these quarries below the level of the railroad track, on account of the great expense and difficulty which would be incurred in loading the cars, though the material below this level is deemed quite as good for all the purposes for which the stone is used. Several houses in Harrisburg are of this stone, notably the residences of Hon. Simon Cameron and Senator J. D. Cameron. Several miles to the westward of the Bridgeport quarries, at Shiremanstown, this limestone is quarried for building purposes and as a fertilizer. It is here blue-black in color, fine, compact, even, and distinctly stratified; the proportion of carbonate of magnesia varies so much that some of the material may be called a calcareous dolomite and some a limestone, strictly speaking. The specimen of dolomite analyzed for this report contained some graphite, some iron, a high percentage of lime, and considerable magnesia; while in another specimen from the same quarry the graphite and iron were wanting, and there was still a greater proportion of lime and less magnesia. The stone is evenly bedded, and the courses vary in thickness from a few inches to 2½ feet. The bed of these quarries is worked only to the depth to which natural drainage is obtained. The dip is about 30°, and stone of a similar quality to that quarried can be obtained to an unknown depth.

In the discussion by Professor Lesley on the analyses of specimens from 115 layers of the rock in these quarries (Bridgeport), which were referred to above, he states that alternate strata of limestone and dolomite

a See Report [illegible], Vol. II, p. 95, [illegible] of the Mesozoic rocks in Pennsylvania.

make up the mass; adding, however, that none of the layers contain a sufficiently high percentage of the carbonate of magnesia to form a true lithological dolomite. The dolomite layers are found to carry the most silicates and other insoluble materials, and as a rule each layer is nearly homogeneous. Magnesia is present in greater or less quantity in all the layers. These 115 layers belong to the lower middle part of the great Magnesian formation, and the chemical analyses show them to belong to two well-marked lithological species, one a limestone carrying 2 or 3 per cent. of magnesia carbonates and 1 or 2 per cent. of insoluble material; the other a dolomitic limestone charged with from 25 to 35 per cent. of magnesia carbonate and an average of over 7 per cent. of insoluble matter, rising in some cases to 10 and 15 per cent., or even more. The largest percentage of the insoluble silicate of alumina is almost invariably found in the higher magnesian layers. From these conclusions of Professor Lesley, and from the conduct of the limestone in the bed of the river and in old buildings constructed of it, this stone is entitled to rank very high as to durability; a comparatively high percentage of insoluble matter may have something to do with enabling it to resist water-wear and other weather exposure. As a matter of course, a soluble or otherwise easily-destructible cementing matter will disintegrate a rock, even though its chief constituents be indestructible fragments so cemented together. The specific gravity of the specimens analyzed range from 2.68 to 2.85.

In Cumberland county about one farmer out of every ten quarries this stone in a small way for local building purposes, and for plaster, fertilizers, etc. The same may be said of Franklin county, and in fact of the whole region of Pennsylvania where the formation outcrops. It would be difficult to give an intelligent estimate of the amount of the material which is quarried in this way outside of the more important quarries, though the figures, if arrived at, would be very considerable.

Progressing still farther down the Cumberland valley, we find that at Carlisle stone is quarried for caps, sills, and bases, and all ordinary building purposes; also for plaster and for fertilizers. The stone is here blue-black in color, fine in texture, and indistinctly stratified; it is evenly bedded, lying in layers from a few inches to several feet in thickness, and in some places very much and at others but little jointed. It is here a calcareous dolomite containing a little iron. In the vicinity of Carlisle much of the rock is gathered from the surface of the fields, where it is an obstruction to farming operations, and nearly all that is needed for local use is obtained from the surface blocks. Dickinson College building, which has stood for nearly a century, and several churches and private residences in Carlisle and vicinity are built of this stone; and the only way in which it seems to have been affected by the weather is that in the older buildings it has faded to a lighter color.

At Chambersburg, Franklin county, in the Cumberland valley, this stone is very similar in every way to that quarried near Carlisle: it is blue-black in color, fine and compact in texture, and the stratification is indistinct and sometimes not observable. The specimen analyzed for this report proved to be calcareous dolomite containing some graphite. The ledge at these quarries is generally worked to the depth of about 20 feet, which is as deep as it can be worked without resorting to artificial drainage. The stone is evenly bedded, the courses being from 2 to 4 feet in thickness usually, and are readily taken out by plug and feather in convenient shape for building purposes. Many farm-houses and barns in the surrounding country are built of this stone; some of them have been standing for a century, and show no evidence of being affected by the elements excepting to fade to a lighter color. Numerous small quarries in this ledge are being operated throughout Franklin county to obtain material for plaster and for fertilizers, and the amount thus quarried each year is very considerable. It is also extensively quarried, throughout the regions of Pennsylvania where it is exposed, for macadamizing streets of the cities and towns and the roadways through the country: it is admirably adapted to this purpose. Another characteristic of this stone, which has been before mentioned in connection with the quarries at particular localities, is its great durability and resistance to atmospheric conditions, with the one exception of its fading to a light color. In Chambersburg old buildings constructed of this stone are sometimes painted so as to imitate very nearly the original color, which is a dark blue or blue-black.

Near Columbia, Lancaster county, the Lower Silurian limestone is quarried extensively at the Kauffman quarry, chiefly for railroad ballast and lime-burning. It is gray in color, massive, fine, and semi-crystalline in texture; it is a calcareous dolomite, containing a little protoxide of iron; and, although having considerable magnesia in its composition, it is very extensively used for furnace flux. The total height of the face of the quarry is 85 feet, and the courses are from 2 to 10 feet in thickness. The strata are inclined at various angles, there being considerable irregularity. There are two different ledges of the limestone in this quarry, disposed non-conformably to each other, though the character of the materials is about the same. The material is not so brittle as the limestone of the Trenton age quarried for ballast at Orbisonia and Morell, in Huntingdon county, and therefore requires more labor in breaking up. There is a marked difference between the stone in the Kauffman quarry and that quarried immediately across the Susquehanna at Wrightsville, in York county. The latter is white and otherwise apparently much altered by metamorphic action, and differs from the Montgomery County marbles in being less crystalline.

At Wrightsville, in the quarry of Kerr, Weitzel & Co., the limestone is of a white and light gray color and fine, compact texture; it is a calcareous dolomite, the proportion of magnesia being considerable.

The following is an analysis of samples of four different varieties of this limestone, made by the state chemist of Maryland in Baltimore, in 1857, with a view to introducing it extensively as a fertilizer in the country bordering the Susquehanna river and upper Chesapeake bay, to which place there is ready access by canal:

	1.	2.	3.	4.
[illegible]	[illegible]	[illegible]	100.0	100.0
[illegible]	97.1	80.8	[illegible]	85.0
[illegible]	[illegible]	14.7	3.1	4.5
[illegible]	[illegible]	4.5	1.5	10.5

The limestone from quarry No. 1 is of uncommon purity, and its lime is especially adapted to application on white-oak soils. The limestone from quarry No. 2 is a weak magnesian limestone; its lime is well adapted to application on soils which are moderately deficient in both lime and magnesia. These are in particular the volcanic soils of some counties in Maryland. The stratum in this quarry is 70 feet in thickness, and is tilted up to an angle of about 45°; and, though the inclination is different at different places, there is no considerable irregularity. The material at the point where quarried has been so much changed, apparently by metamorphic action, that it has very much the appearance of what are commonly called marbles, excepting that crystallization is not so apparent. The color is sometimes white, sometimes bluish. There is no regular division into layers, the stone being simply a much-jointed mass; and it would not be practicable to obtain large, regular blocks for building purposes. The railroad depot at Columbia is built of small, irregular blocks of this material, firmly cemented together in the style commonly known as rock-faced work. It presents a very pleasing appearance, and stone for this style of construction can be obtained in inexhaustible quantities here. The stone which is now quarried is the No. 1 given in the analysis, and is chiefly burned for a fertilizer and for building lime on the eastern and western shores of Maryland, to which, as before mentioned, there is ready access from the quarry by water, although some of it is now shipped by rail.

A specimen of the Lower Silurian limestone forwarded by E. V. D'Invilliers, of the Second geological survey of Pennsylvania, from near Yellow House, in Berks county, is a bluish-gray, fine, compact, indistinctly-stratified magnesian limestone containing a little iron.

The great Magnesian limestone formation which extends across Pennsylvania from the Delaware river to the Maryland state line, along the north foot of the South mountains, sinks northward and rises again to the surface in the valleys and coves among the mountains of middle Pennsylvania, viz, in McConnellsburg cove, Kishicoquillis valley, Morrison's cove, Nittany valley, Spruce Creek valley, etc.

A specimen from Spruce creek, Huntingdon county, is a blue-black, fine magnesian limestone, compact in texture, and breaks with a conchoidal fracture. It contains graphite.

Some description of the limestone in this region may be found in Vol. I, p. 500, of the *First Geological Survey of Pennsylvania*. This great limestone formation in Pennsylvania was called by Rogers the "Auroral" limestone, and it is termed by the *Second Geological Survey of Pennsylvania* the Siluro-Cambrian, and quite as often the magnesian limestone, from the universal presence of magnesia in greater or less quantities. The same authority also has local names for it in different parts of the state, as the York limestone, in York county; the Lancaster limestone, in Lancaster county, and the valley limestone in Chester county. For analysis of the Siluro-Cambrian limestone see Report M M, p. 304, *Second Geological Survey of Pennsylvania*.

DEVONIAN.—The only Devonian limestone quarried extensively in Pennsylvania is the Corniferous, of which there are massive beds exposed in the mountain regions in the central part of the state, and which are chiefly used for furnace flux and railroad and turnpike ballast.

Among the principal quarries on this formation are those of the Warrior ridge, at Huntingdon, where the stone is quarried for ballast by the Pennsylvania railroad. It is here a dark drab, fine, compact, and brittle material, non-fossiliferous, and contains graphite, some iron, and little magnesia. According to the system of nomenclature observed in this report it is a true limestone. The total thickness of the ledge is about 100 feet, disposed in layers varying from 8 inches to 3 feet. There are two layers of shale, each about 4 feet in thickness, one about 25 feet from the ledge, the other 5 feet lower, with limestone between. Numerous seams of calcite run through the stone. It is used only as ballast at present. It is said to furnish but a poor, mean lime when burned, and is not suitable for furnace flux.

For a description of this ledge of Corniferous limestone in the Juniata valley see Report F, *Second Geological Survey of Pennsylvania*. It contains few or no fossils, and in this respect differs radically from the highly fossiliferous Corniferous limestones of Ohio and other parts of the west.

Farther to the south, along the Warrior ridge at Cove station, in Huntingdon county, on the Broad Top railroad, the Shirley quarry is extensively worked for furnace flux, which at present is chiefly used by the Kemble Coal and Iron Company at Riddlesburg, Pennsylvania, to which place it is transported by rail. The ledge at this place is at least 200 feet in thickness, and possibly much thicker; it dips at an angle of 60°, giving the strata a

very fine position for quarry operations. One particular division of the strata deserves special notice: it is about 15 feet in thickness, divided into layers from 2 to 4 feet in thickness; is uniform in character throughout, and, according to an analysis made for the Cambria Iron Company of Cambria county, contains 98.55 per cent. carbonate of lime. It is drab in color, massive, and coarsely crystalline in texture, containing a very little iron and magnesia, and is susceptible of a good polish. It is locally known as the "fossil" limestone as distinguished from the rest of the ledge, which is non-fossiliferous. The fossils are chiefly three or four different species of brachiopods, found on the surfaces of the layers, but not within the stone, as when fractured it shows a uniform, highly-crystalline texture, as is also true at other quarries of this ledge.

The non-fossiliferous part of the ledge, according to the analysis for the Cambria Iron Works, contains 94 per cent. of carbonate of lime; is very hard, compact, and brittle, breaking with conchoidal fracture, and would not in its natural condition be well adapted for purposes of construction, excepting for ballast on railroads and turnpikes. Only that portion of this ledge, 65 feet in thickness, which extends above the level of the stream is quarried. The rapid dip of the strata carries it beneath the surface an unknown distance.

Still farther south on the Warrior ridge, at Hyndman, at the junction of the Broad Top and Baltimore and Ohio railroads, this Corniferous ledge is quarried for furnace flux for use in Pittsburgh, to which place it is transported by rail. The stone is here a dark drab, massive, magnesian limestone, containing a little protoxide of iron and magnesia. It is fine, hard, and brittle in texture, and breaks with a conchoidal fracture. The face of the quarry is 200 feet in depth, and the strata are tilted to a vertical position.

Although the strata in all the mountain regions of Pennsylvania are usually tilted at a variety of angles, it is unusual to find strata of limestone perfectly perpendicular. The layers vary in thickness from 1 foot to 2 feet in that portion of the ledge quarried. A width of about 50 feet of the strata is quarried at present, the quarry progressing into the hill, and the uptilted layers of limestone on each side forming perpendicular walls.

A considerable part of the whole ledge is made up of layers of shaly, thinly-bedded limestone. Seams of calcite are frequent. It exists in inexhaustible quantities here, and the amount quarried for furnace flux, lime-burning, and fertilizers is increasing rapidly, as new quarries on the ledge are being started.

Warrior ridge, upon which the Corniferous quarries at Huntingdon, Cove station, and Hyndman are located, is an outcrop of the Oriskany sandstone formation, which crosses the Juniata river a little above Huntingdon, and ranges northeast and southwest for many miles parallel to and facing Tussey mountain, from which it is separated by the valley of the Lower Helderburg limestone and Clinton red shale (fossil iron ore). Its crest and escarpments are cut into remarkable "pulpit rocks". The dip is usually gentle to the southeast, but there are local anticlinal rolls, with very steep or vertical northwest dips. The return of the outcrop east, south, and southwest, around the head of Standing Stone valley, brings the Oriskany and the limestones above and below it back to the Juniata at the glass-sand quarries below Huntingdon, in Jack's narrows.

Sub-Carboniferous.—The only extensive limestone quarry producing stone for purposes of construction on other than Lower Silurian rocks in Pennsylvania is on the umbral or mountain limestone, a division of the sub-Carboniferous in Pennsylvania.

This quarry is located 3 miles southeast of Connellsville, on the Baltimore and Ohio railroad, in a gap made by the Youghiogheny river in the Chestnut Ridge mountains, through which the railroad passes. The ledge on which this quarry is situated is one of the strata forming the anticlinal axis of Chestnut ridge. There is considerable dip of the strata to the northwest away from the crest of the mountain, the general direction of which is north-northeast and south-southwest. The joints in this quarry are about 15 feet apart, the ledge not being so much broken as is the case with nearly all the mountain ridges of Pennsylvania. The total thickness quarried is about 80 feet, with the bottom not reached, and the material is disposed in courses from 10 to 14 feet in thickness. Professor Stevenson, in Report K K of the *Second Geological Survey of Pennsylvania*, describes it as very compact, blue, breaking with a conchoidal fracture, and in general appearance bearing a close resemblance to quartzite. The analyses of specimens made for this report show it to be properly a limestone, containing some silica, protoxide of iron, considerable lime, and very little magnesia. Professor Stevenson describes the stone as essentially a sandstone, with cementing material of calcium carbonate, but analysis shows that it contains a sufficient proportion of carbonate of lime to be properly a limestone. It is a bluish-drab in color, fine and subcrystalline in texture, and evenly bedded.

In Pittsburgh, where there is much heavy traffic over the streets, it has given good satisfaction as a paving material; it is very hard and compact, resisting wear exceedingly well, and it is readily shaped with the hammer into rectangular blocks of a proper size for paving.

This ledge has been thought to correspond with the Maxwell limestone of southern and eastern Ohio; in Pennsylvania it is variously called the siliceous, umbral, or mountain limestone, and lies on the Pocono or Vespertine sandstone, at or near the horizon of the Waverly series of Ohio, the formation producing the fine, compact sandstone so much quarried at Amherst, Berea, Brownhelm, Waverly, and other points on the sub-Carboniferous outcrops extending through the central part of Ohio from its northern to its southern limits.

During the census year 52,000 paving blocks from this quarry were used in Pittsburgh.

CARBONIFEROUS.—The Carboniferous limestones of Pennsylvania are but little used for purposes of construction. At Van Port, Beaver county, on the Ohio river, there are quarries on the ferriferous limestone, *a*, and the material is used chiefly for lime and furnace flux, though it has been employed to a slight extent for walls and foundations. The stone is a massive magnesian limestone, fine and fossiliferous in texture, containing a little protoxide of iron. The total thickness of the ledge is about 11 feet, divided into three principal layers, of which the upper is 4 feet in thickness, the middle 3 feet, and the lower 4 feet. Thin shaly layers usually cover the top, and sometimes intervene between the principal layers. The middle layer resists the action of the elements and is susceptible of fine dressing. Although the color of this limestone is a bluish-gray where the face of the ledge is exposed, it weathers with a peculiarly wrinkled, russet-colored appearance. It is highly valued as a furnace flux, and is used chiefly at Allegheny, Pennsylvania, Wheeling, West Virginia, and Mingo Junction and Steubenville, Ohio.

TRIASSIC.—At various places near the South mountain, in Pennsylvania and Maryland, the Triassic (Mesozoic) formation consists of a calcareous conglomerate, made up chiefly of fragments of the magnesian limestone upon which it rests, and which bounds it on the northwest, cemented with a red clayey material, very calcareous from infiltration, and in Maryland called Potomac marble. When polished, the stone presents a very singular but pleasing appearance from the numerous fragments of which the mass is composed. A chemical analysis shows its ingredients to be about the same as those of the limestone, from which it is chiefly made up. A specimen from near Fairfield, Adams county, forwarded by A. E. Lehman, of the Pennsylvania geological survey, proved to be a dolomite, containing considerable reddish residue, clay-cementing material, and a little iron, which gives the clay its reddish color. It is here burned for lime. Its local name is "calico rock", from its peculiarly diversified appearance.

SANDSTONES.

TRIASSIC.—The geographical limits of the belt of Triassic age passing through southeastern Pennsylvania are described in the geological reports of that state as commencing at the west bank of the Hudson river in a broad belt extending from the bay of New York to the base of the first ledges of the Highlands, and as bounded on the northwest by this chain and its continuation: southwestward it traverses New Jersey, Pennsylvania, Maryland, and, in a more interrupted manner, Virginia and part of North Carolina, so that its total length is not less than 500 miles, with a width in New Jersey of 20 miles between the Hudson and the Highlands. After crossing into Pennsylvania its breadth expands to nearly 30 miles, retaining this until it approaches the Schuylkill, when it contracts and maintains its course through Berks, Lancaster, Lehigh, Dauphin, York, and Adams counties, a breadth of about 10 miles between the Schuylkill and the Susquehanna rivers, and of 15 miles between the latter river and the Maryland state line. The south margin of the formation crosses the Delaware about 1½ miles above the town of Trenton, and the north border crosses the Delaware at Durham, near Trenton. The geology of this formation is very simple, and is made up chiefly of red sandstones and shales alternately, the arrangement being in many places layers of sandstone of various thickness, with red shale intervening. The lowest portion of the formation is a conglomerate, chiefly made up of fragments of the primal rocks and limestones upon which it rests; then comes a considerable thickness of the red shales and sandstones, surmounted by the calcareous conglomerate, or "calico rock", just noticed. The sandstones in the middle part of this formation is the portion which produces nearly all the building stone at present quarried from the formation.

One of the principal quarries in Pennsylvania, on rocks of this age, is at Hummelstown, Dauphin county, a few miles east of Harrisburg. The material here is a brown, massive sandstone of a uniform and medium texture, and is quarried for caps, sills, trimmings, bases, steps, and other building purposes. It has been much used in Philadelphia, Harrisburg, Williamsport, Pottsville, Reading, Lancaster, York, Richmond, Baltimore, Washington, and other cities of the east. The ledge is 85 feet in thickness in this quarry, dipping perhaps 40° to the northward, and outcrops in places, the stripping setting in and increasing as progress is made into the hill. It may be observed here that the dip of this Triassic sandstone in Pennsylvania is almost universally in a northerly direction, and remains steadily between about 15° and 40°. But there are remarkable exceptions to this rule, as shown on the sheets of the topographical map of the Durham hills and Reading mountains (by Berlin and D'Invilliers), published in the atlas to Prime's Report D D D, *Second Geological Survey of Pennsylvania*. A considerable tract east of Reading is covered with south dips varying from 40° to 75°. There are south dips alternating with north dips along the Schuylkill below Reading, and Professor Frazer reports local anticlinals in York county.

The quarry is located on the south side of a hill. The stripping is not great, from the fact that the ledge is inclined at such an angle (40°) that it may be followed downward without the necessity of taking off much cover. The face of the quarry is at present about 100 feet, which is greater than the real thickness of the ledge, a fact due to its inclination. The rock is evenly bedded, and in courses varying in thickness from 3 to 10 feet. Blocks of as

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large a size as are desirable may be taken out. The jointing is rather regular, and the joints are from 1 to 40 feet apart. The topmost courses are of a reddish-brown color, resembling very much that of the Connecticut brownstone of the same formation, but the great body of the material is of a uniform, characteristic bluish-brown color, by which it is readily distinguished. Plate W represents a dressed surface of the Hummelstown brownstone. Among the buildings in which this stone has been chiefly used for trimmings are: In Washington, District of Columbia, the Bureau of Engraving and Printing and the residences of Hon. James G. Blaine, Senators Sherman and Cameron, and Colonel Jerome Bonaparte; in Philadelphia, the Academy of Fine Arts (basement), old Trinity church, Academy of Sciences (basement), and Philadelphia library. A slab from this quarry was forwarded to the National Museum which has every indication of having been formed by being sun-baked when in a soft, plastic state, the cracks being filled by material swept over them by the waves. In the quarries at Goldsboro', York county, the surfaces of some of the layers contain what resemble worm tracks or borings, and the stone is of a medium-fine texture, some of it conglomeratic, small siliceous pebbles being present; it is a reddish-brown in color, and has been quarried for caps, sills, steps, base courses, and trimmings generally, and is used in York, Harrisburg, Danville, Williamsport, and other cities in this part of Pennsylvania. Some of the trimmings in the Pennsylvania Capitol building are of this stone. It was not quarried during the census year. The total thickness of the ledge quarried is about 25 feet, in courses varying from 1 foot to 10 feet in thickness, with layers of red shale intervening between many of the courses of stone. The portions of the ledge nearest the surface are not so compact and durable as those below; this is, however, a characteristic of nearly all sandstone quarries. The distance from the railroad station is about 2½ miles.

Along the line of the Philadelphia and Reading railroad, in the vicinity of Mohn's store, several miles south of Reading, Berks county, the Triassic sandstone, here a reddish-brown, massive stone of uniform medium-fine texture, not differing greatly in appearance from that quarried at Goldsboro', York county, is quarried from surface rocks, which are scattered thickly over the ground, and is used for steps, caps, sills, fronts, base courses, and other trimmings, chiefly in Reading, where several churches are built of it. The ledge of sandstone is found in place, but the stone is not quarried, as there is a supply of the surface rocks fully seasoned by the weather, furnishing a reliable and durable material, while some of the layers of the Triassic sandstone in place show themselves, when first quarried, to be susceptible to the action of dampness and frost, and need some care in seasoning. Many of the farm buildings through the area covered by this formation in Pennsylvania are constructed of the sandstone from it. The color is always some shade of brown, or reddish-brown, from the intimate dissemination of iron oxide through the cementing matter.

Within the limits of Norristown, Montgomery county, and the immediate vicinity of the city, the Triassic sandstone is quarried in a small way for local purposes, such as cellars, foundations, and ashlar for walls and fronts. The quarry just west of Bridgeport, across the Schuylkill from Norristown, ships a small amount of stone to Philadelphia. The location here is not far from the southern edge of the formation, and the stone quarried is from its lower strata, with a coarse, almost conglomeratic, texture and somewhat lighter color than the rock quarried higher in the strata. The total thickness of the ledge quarried here is about 14 feet, disposed in regular layers varying in thickness from 9 inches to 2 feet, some of which are separated by thin partings of the reddish clay. It is considerably jointed and broken. It is probable that layers of the stone lie below the bottom of the quarries at present opened in this vicinity. The stone presents a rougher appearance than that obtained from the same formation in most of the other localities where it is quarried, and it is of a lighter color, sometimes having only a tinge of brown. The color is not uniform throughout the quarries, and the buildings constructed of it in Norristown have a variegated appearance on this account, though there is not enough of variation to make the walls of the buildings present violent contrasts of color. This stone in the walls of buildings constructed of it over half a century ago still remains firm and durable, but its grade is not such as to make it important for other than local uses.

At Lumberton, Yardleyville, Center Bridge, and other places in Bucks county, near the Delaware river, the Triassic sandstone is quite extensively quarried for cellars, foundations, bridge abutments, and ashlar, and is shipped chiefly to Philadelphia by rail and boat; it is also shipped to Camden, Norristown, and neighboring places. The material here is of medium texture, with indistinct signs of stratification, and usually of a light brown color. The quarries are on the lower portions of the strata. The bedding is fine and the courses are thick and regularly jointed, being usually from 8 to 20 feet apart. Among the buildings constructed of this material are the Bucks County court-house, at Doylestown; the insane asylum, Norristown; approaches to the South Street and Callowhill Street bridges; the Catholic churches at Lehigh avenue and Diamond street, and the wing of the Episcopal hospital, Philadelphia.

At Newton, in Bucks county, a small amount of stone is quarried, the material being similar and used for the same purposes as that at Lumberton and Yardleyville.

The stripping in all of these red-sandstone quarries is a red clay, and varies in depth from nothing to 12 or 15 feet, excepting in the Hummelstown quarries, where the stripping is sometimes greater. As the ledge always has considerable dip, it outcrops in places and the stripping increases more or less rapidly according to the topography of the ground.

LOWER SILURIAN.—Outside of the Triassic border to the north and west, middle Pennsylvania is a country of parallel sandstone mountains and shale and limestone valleys, of which the principal sandstone formations are the Oneida and Medina (No. IV), the Oriskany (No. VII), the Catskill (No. IX), the Pocono (Vespertine, No. X), and the Pottsville Serai, No. XII; but in none of these except the Catskill have quarries of building stone been opened for commercial purposes, although the sandstones and conglomerates have been locally used for building purposes.

The South mountains, which rise immediately from the north border of the Trias belt, are made up of Laurentian gneiss overlaid by Potsdam sandstone between the Delaware and Schuylkill rivers, and of Potsdam sandstone and Huronian porphyries between the Susquehanna river and the Maryland line.

The Welsh mountains, on the south edge of the Trias belt, in Chester and Lancaster counties, is Potsdam sandstone overlying (Laurentian?) gneiss. This Potsdam sandstone formation extends westward underground beneath the limestone plain of Lancaster and appears on the Susquehanna river above Columbia.

Both above and below the Potsdam sandstone (quartzite) proper lie schists or slates which belong to the same formation and ought to bear the same name. The upper slates are calcareous and underlie the great Magnesian limestone (Lower Silurian) formation of the Cumberland valley.

There is a quarry of Potsdam sandstone at Columbia, Lancaster county, in beds immediately underlying the Siluro-Cambrian limestone. It is used only for cellars, foundations, furnace stacks, and work of that class in Columbia, Harrisburg, and vicinity. The height of the face of the quarry is about 110 feet, in layers varying from 3 to 20 or 30 feet in thickness. The strata are perpendicular and are sandwiched between strata of magnesian limestone. The horizontal measurement across the face of the quarry is from 1,200 to 1,300 feet. These two formations apparently form an anticlinal axis from which the top has been eroded. The stone is invulnerable to the attacks of the weather, is dry, and will absorb but little moisture; it has no regular cleavage and is somewhat difficult to get into proper shape for any but the ruder uses. It stands a high degree of heat. The material is fine-grained, calcareous, massive, compact, gray in color, having somewhat the appearance of an argillaceous schist, and breaks with a very irregular fracture.

In Northampton county, near Bethlehem, there is a fine, massive, gray, hard, and rather quartzitic sandstone of the Potsdam formation, lying in thick layers and irregularly jointed, quarried for local purposes.

UPPER SILURIAN.—Rocks of Upper Silurian age are but very little quarried in Pennsylvania for building purposes.

Two miles north from Danville, on the line of the Bloomsburg division of the Delaware, Lackawanna, and Western railroad, and on the north branch of the Susquehanna river, in Montour county, rocks of the Clinton subdivision of this formation are quarried for building purposes and for heavy foundations. It is a dark gray sandstone, massive, fine in texture, evenly bedded, and lies in medium to thick courses. This stone was used in the construction of the Danville insane asylum.

Near Mapleton, Huntingdon county, at the west entrance of Jack's narrows, a deep gap in Jack's mountain, letting the Juniata river and the Pennsylvania railroad pass through, the face of the mountain is covered with surface rock of Medina sandstone to a depth of 50, perhaps 100, feet or more in places, making the mountain appear from some points like a huge stone heap. The stone is a light gray in color, of medium texture, irregular in stratification, very hard, and only less brittle than the limestone much quarried in the mountain region of this part of the state for railroad ballast. The stone here is used for railroad ballast and bridge abutments on the Pennsylvania railroad. It is very durable, resisting the elements well; blocks large enough to produce stone for bridge abutments do not occur often enough to furnish a convenient supply. Considerable selecting is necessary when blocks of this kind are desired, but the blocks are flat-bedded and large enough to be used for foundation and cellar work and for ashlar. The only labor necessary at this quarry is the breaking of the stone and sending them down the chute to the cars below. For description of Medina sandstone in Juniata valley see Report F, *Second Geological Survey of Pennsylvania*.

At the upper end of Jack's narrows the Oriskany sandstone is quarried extensively for glass-sand; it is too friable at this point to answer for building purposes. The strata stand vertical or with a very steep westerly dip.

DEVONIAN.—At Weissport, in Carbon county, there is a fine, thin, and evenly-bedded carbonaceous sandstone of the Marcellus Shale age quarried to a limited extent for flagging and other uses at Weissport, Mauch Chunk, and Bethlehem: it is dark gray, approaching black in color, due probably to the carbonaceous matter in it. The depth of the material quarried is about 12 feet, out of which about 5 feet are suitable for flagging, the workable material being disposed in beds a foot or two thick through the mass. The flags are from half an inch to 8 inches in thickness; dip of the strata, 20°.

The Marcellus shale in this vicinity is reported to contain sufficient carbonaceous matter to occasionally amount to a thin streak of bituminous coal; and this is a characteristic feature of the formation in many counties of the state. In Perry county it contains numerous thin streaks of coal.

Next in order, progressing to the northward, in eastern Pennsylvania are the Catskill beds, which contain the flag-stone quarries of the Delaware River valley, above Port Jervis, in Pike county. The rocks here quarried have been by the *Pennsylvania Geological Survey* named "Delaware flags". They are quarried chiefly for sidewalk

paving and other flagging, and for curbs and trimmings. It is dark grayish, usually massive, but sometimes indistinctly stratified, fine, compact, and hard in texture. It lies usually in even parallel layers from 1 inch to 12 inches and upward in thickness. It is marketed in Philadelphia, Newark, New York, New England, and Washington, and is known as the New York blue-stone, going into the market with stone from Ulster county, New York, from which material it is scarcely distinguishable.

The surface of the country in this section is very hilly and rugged. The strata are nearly horizontal, and the roughness of surface has been produced by erosion simply.

The flags are quarried along the face of the steep cliffs, on both sides of the river, at a number of convenient points where the fallen debris is not too thick. On starting a new place the quarrymen usually have to remove about 6 feet of worthless rock, getting about 4 feet of flags, increasing from 1 inch to 12 inches in thickness from the top downward. Below this the layers continue to increase in thickness, and are considered too thick for flagging. Machinery has not been used except as an experiment. Some of the Pike County flag stone is quarried at higher elevations and is of a somewhat lighter color than that which is quarried lower. The method of transportation to Philadelphia, where much of the stone is used, is by canal to Rondout on the Hudson, thence round by water, but to points in New York, New England, and New Jersey usually by rail, so as to avoid transfer.

The Catskill sandstone is quarried in the mountains near Scranton, chiefly for local use in bridge abutments, cellars, and foundations. It is here of a buff color, medium hard in texture, indistinctly stratified, and lying in even parallel seams from 3 to 20 inches in thickness; the joints are usually from 12 to 15 feet apart. The quarry is located in a mass of stone exposed on the northwest side of the mountain west of Scranton. There is no stripping; the dip of the strata northwestward is about 25°; the thickness of the beds quarried 30 feet. The blocks readily break into rectangular shapes with proper management. As nothing but cobble pavement, and but little of that, has thus far been used in Scranton and neighboring towns, there has been no demand that would justify a trial of the experiment of shaping this stone into paving blocks. It is stated in the geological reports that the lithological characteristics of this ledge are those of the Pocono sandstone, but that there are some stratigraphical relations that indicate it to be Catskill.

In the mountains a few miles east of Wilkesbarre, in Luzerne county, the Catskill red sandstone is quarried for sidewalk-paving, caps, sills, and ashlar. The stone here is quartzitic in appearance, of medium texture as to firmness, and lying in even parallel courses of thin to medium thickness, with beds inclined at various angles according to locality; the joints range from 20 to 40 feet apart. It is shipped by rail to Wilkesbarre, Allentown, Bethlehem, Easton, and neighboring towns. This formation is the principal one exposed on the side and crest of the mountain which borders the Wyoming valley on the east. The soil on the mountain is sterile and scant from the slow weathering of the rock. There is but a scanty growth of cedar, hemlock, pine, and scrub brush, the crests of some of the ledges being entirely bald. The thickness of the workable stone in the quarries now opened is from 8 to 10 feet, in courses from 1½ inches to 2 feet in thickness, the thin layers lying usually near the top, but sometimes intervening between thicker layers. Nearly all of the sidewalks in Wilkesbarre are paved with this stone. In the locality where the quarrying is done at Laurel run the dip of the strata is into the mountain. The stripping increases very rapidly, and the quarrymen keep around the skirt to avoid deep stripping.

The Chemung beds of Wyoming county rank very high in the production of building stone. The material is quarried for all building purposes, and chiefly for caps, sills, bases, monuments, and trimmings. It is used in New York, Philadelphia, Boston, and Washington. The stone is fine, compact, massive, dark bluish-gray in color, lies in even parallel layers from a few inches to 6 feet or more in thickness, the courses at the top being usually thin, and increasing in thickness downward; the thicker beds are quarried extensively for flagging. The surface of the country is very broken and hilly, the hills being usually steep and rocky, showing the resistance of the stone to decomposition. Beds of good stone for flagging and general building purposes are found here and there at all elevations, flaggings of the same quality, texture, and general appearance being found at the foot and at the summit of the same hill; from 6 to 20 feet of good stone may be found at one place. The abruptness of the hills usually causes the stripping to increase rapidly; the strata are nearly horizontal, the broken character of the country being caused by erosion. This stone does not scale or crumble. The expense of dressing the stone is comparatively high, but it is thought to fully repay for its costliness by the handsome and substantial character of the work constructed of it. The quarries at Black Walnut, Skinner's Eddy, and Nicholson, all in Wyoming county, are of the same formation, and the material is the same as to quality. Gang and rip saws, rubbing-beds, and turning-lathes are used in dressing the stone. This stone has been used in the construction of the Produce Exchange building, the residence of Mr. W. J. Hutchinson, on Fifty-eighth street, and that of Mr. Addison Hutton, Fifth street, New York city; the residence of Mr. A. J. Dull, at Harrisburg, and the carved work for the interior decoration of St. Mark's Episcopal church at Mauch Chunk, Pennsylvania. Other quarries in this vicinity produce flagging exclusively from the thinner layers. The surface layers are usually not solid, but have a sort of laminated structure, and can readily be split into thin plates; such flags prove to be inferior, on account of the separation of these plates by the water and frost. Considerable of the stone from these layers is shipped, but sells at a lower price. The lower courses are solid, quite substantial, and durable. For the past few years the amount of flagging shipped from this locality each year has been more than double that of the preceding year.

In beds at apparently the same horizon as those quarried at and near Meshoppen, stones similar in character are quarried for flagging, steps, water tables, caps, sills, and monument bases, at Nicholson, about 20 miles east of Meshoppen, and are shipped to Scranton and vicinity and Easton, Pennsylvania, and to Hoboken and Morristown, New Jersey. Twelve feet in thickness of the ledge is quarried, but the bottom has not been reached. The courses are very even, and parallel and horizontal, varying in thickness from 1 inch to 3 feet, the thinnest layers at the top, though thin layers often intervene between the thicker ones. The section of country in which the quarry is situated is hilly and broken, caused by erosion, apparently, as the strata are all horizontal. The hills are made up mostly of stone, generally lying in thin layers. Where the quarries are located at the base of these steep hills the stripping increases rapidly.

At Brandt, in Susquehanna county, on the Delaware and Hudson Canal Company's railroad, the Chemung beds are quarried for flags, curbing, crossings, caps, sills, and other trimmings, which are shipped to Elmira and Binghamton, New York, and to Scranton, Pennsylvania, and vicinity. The stone is massive, fine and hard in texture, dark gray in color, and lying in even parallel courses from 2 to 8 inches in thickness; the joints are 10 feet and more apart. Where quarried there are about 25 feet in stripping of cap or worthless rock, under which is a bed of good flagging 12 feet in thickness, lying horizontally; flags at the top are about 2 inches thick, and they increase very regularly in thickness downward, the bottom flag being 12 inches thick; beneath the flagging is a bed of brittle, crumbling slate. The surface of the country here is very rough and broken, and beds of the flagging occur at almost every elevation.

At Mainsburg, Tioga county, the Upper Chemung beds are quarried for paving flags, which are shipped to the neighboring towns in the south-central part of New York. The stone is dark gray, sometimes massive, and sometimes distinctly stratified, lying in even, thin, and horizontal courses. The bed of the quarry is about 8 feet in thickness, covered by a solid stratum of hard, dark colored shale, which is removed by drilling and blasting. The courses are from 1 inch to 8 inches in thickness, most of them being less than 4 inches. The 3- and 4-inch courses make very desirable material for sidewalk flagging, the thinner courses being adapted only to use in pavements which are not required to sustain much wear nor heavy shocks. The natural blocks are usually nearly square and quite evenly and smoothly bedded. The bed will at the present rate soon be exhausted in the hill where it is now quarried, but it is probable that in some of the surrounding hills beds of equally good quality exist. An ordinary paving material is quarried in the Red Catskill formation near Wilkesbarre and Osceola, Tioga county.

Sandstone of Chemung age is quarried at Farrandville, Clinton county, for ordinary building purposes, and is used chiefly at Danville, Montour county, Pennsylvania. It is buff in color, massive, and of medium texture, lying in even courses of varying thickness. The front and tower of the Bloomsburg jail, the Memorial church at the same place, and the Danville National Bank building are constructed of this stone.

At Queen's run, in Clinton county, Devonian rocks of Catskill age are quarried for foundations and bridges, and are used chiefly at Lock Haven, to which place they are transported by water. The stone is fine in texture, indistinctly stratified, dark gray and brown in color, and lying in even courses of medium thickness. The use to which this stone is most applicable is curbing; it is used in the rough for cellar walls and bridge abutments, sometimes rough-pointed for these purposes. Some of the courses make an ordinary material for sidewalk pavement. The stone has been quarried at various localities in the vicinity along the bank of the river. The strata of quarry rock are found at different horizons; they are usually but a few feet in thickness, and the dip soon carries them under, so that they are not quarried extensively at any one locality.

The Oriskany sandstone has been extensively quarried for bridge abutments and wall stone near McVeytown, and is used for bridge abutments and wall stone at Harrisburg, Pennsylvania, and along the line of the Pennsylvania railroad, chiefly on the middle division. It is gray in color, coarse in texture, its stratification is even and parallel, lying in even, regular courses of varying thickness. Up to the present time only the surface rocks have been quarried at this place; they are scattered over the sides and top of a low anticlinal ridge of Oriskany sandstone lying just east of McVeytown and parallel to Jack's mountain, which rises a couple of miles to the west. It is estimated that $1,000,000 have been expended on this ridge in quarrying and preparing this stone, chiefly for bridge abutments on the Pennsylvania railroad. It is rather rough in texture, but very hard and durable. The sandstone usually has a ripple-marked surface, but the natural blocks are usually rectangular in shape and nearly as regular as if sawed. The much-weathered rocks on the crest of the ridge exhibit casts of a brachiopod (probably the *Spirifer arenosus*) in abundance. There is yet a large supply of the stone in the shape of surface rocks, and, because less expensive, they will probably all be removed before the rock in place is touched.

The sides of the mountain near Altoona, Blair county, are thickly strewn with surface rocks of different formations, chiefly Catskill, Pocono, Pottsville conglomerate, and Mahoning sandstone, which furnish nearly all the building stone for cellars, foundations, terrace walls, and other ordinary building purposes, and is used in the town of Altoona and vicinity. These surface rocks are gray in color, and, though varying much in color and texture, are usually very hard and durable; on breaking up they exhibit many cracks and fissures, due to the effects of fire passing over the mountains. The material is too rough and hard to dress well, and is only suitable for the ruder building purposes.

At Lebœuf, Erie county, the third oil-sand, locally so called, which is of Devonian age, produces a sandstone used at Erie for foundations, bridges, flagging, sills, and other trimmings. It is gray in color, fine in texture, distinctly stratified, and evenly bedded, the courses being of medium thickness. This formation produces the best building stone quarried in Erie county. When seen in the stone-yards, fresh from the quarry, it can hardly be distinguished by its general appearance from some of the stone quarried at Berea, Ohio. By some geologists the third oil-sand was for a long time supposed to be the equivalent of the Berea grit in Ohio, but it is now pretty generally admitted that the Corry sandstone, several hundred feet above the third oil-sand and above the whole Venango oil group, is the equivalent of the Berea grit. The Corry sandstone in Pennsylvania does not possess the valuable characteristics of its equivalent, the Berea grit, in northern Ohio. There are a number of quarries worked to a limited extent in the third oil-sand in Erie county. The rock of this formation has been quarried in different localities at different times for local and temporary demands, but there are few permanently-worked quarries in the county. The rock contains petroleum and soluble sulphates in such large quantities that it is not a desirable material to be used in fine buildings. Builders say it "sweats and spoils everything below it". It is, however, a good material for bridge-building and other like purposes. The stratum in the quarries is about 11 feet in thickness, the courses varying from 8 inches to 3½ feet thick. A section of the quarry is as follows:

Drift deposit	6 feet.
Blue shale	6 feet.
Coarse conglomerate	1 foot 6 inches.
Quarry rock, sometimes containing pebbles, especially between the beds	7 feet.
Quarry rock, clear, fine-grained sandstone, beneath which shale appears	4 feet.

The stone is quarried chiefly on the left bank of French creek. The stripping constantly increases as the excavation is carried farther into the bank. The outcrop of the quarry rock is about half a mile in length, and a large amount of the stone may yet be quarried with a little increase of stripping.

At Jackson station a quarry is opened in the third oil-sand formation, and experiments are being made with the rock with the expectation of successfully marbleizing it for mantels in the same manner as the Euclid (Ohio) stone.

Devonian rocks of Portage age are quarried a few miles east of Erie for foundations in that city. The stone is gray in color, fine in texture, indistinctly stratified, and evenly bedded in layers of medium thickness. The principal quarry is in a stratum of fine-grained sandstone from 20 to 30 feet in thickness; in some places there are two or three courses from 6 to 12 inches thick, and in some places the stratum is solid. The rock contains petroleum and other soluble impurities which make it unfit for use in all buildings exposed to the atmosphere. Other quarries of the same rock are quarried near the lake shore, the quality of the rock being about the same in all the quarries on this formation near Erie. A blue, impure sandstone in the Chemung flags is quarried occasionally to a limited extent at different localities in the vicinity of Erie.

Sub-Carboniferous.—Rocks of the sub-Carboniferous formation in Pennsylvania have thus far been quarried but little for purposes of construction. It will be noticed that there is but one limestone quarry of importance located on rocks of this age in Pennsylvania, and the following description will give an idea of the extent to which the sub-Carboniferous sandstones are quarried in the state:

Three miles north of Scranton, in Lackawanna county, in the side of the mountain a short distance westward of that city, and close to a quarry in the Catskill sandstone before mentioned, there is a quarry located on rock, probably, though not certainly, of Pocono sandstone of sub-Carboniferous age. The stone is much softer than that in the quarry of Catskill sandstone, and produces the best cutting stone in the vicinity; it is used for base courses, caps, sills, and other trimmings at Scranton, and was used in the construction of the Megargill and Cornell bank in that city. There are 26 feet of workable stone in this quarry, the thickness of the layers being from 3 inches to 2 feet, with the thinnest at the top, although thin layers occasionally intervene between the thicker ones. The dip of the strata is about 25°.

Two miles northwest of Altoona, in Blair county, on the Pennsylvania railroad, sandstone, probably of Pocono age, is quarried for cellar walls and foundations in Altoona. The material is gray, of medium texture, evenly and distinctly stratified, evenly bedded, and in courses varying from 1 foot to 4 feet in thickness. The stratum is much jointed, being usually not farther apart than from 5 to 10 feet. The total thickness of the ledge is about 15 feet. The stratum inclines about 45°, and dips into the hill in such a way as to increase the stripping very rapidly, so that it is not practicable to follow the ledge far into the hill.

Four miles southeast of Uniontown, at the west foot of the Chestnut ridge, the Pocono sandstone is quarried for lining steel furnaces, cupolas, and converting-furnaces. It is used chiefly at Pittsburgh and at Braddock's Field, Pennsylvania, and Saint Louis, Missouri. It has been used in the construction of cellars and foundations. It might be used for ordinary building purposes, but is rather hard to dress; and there is such a demand for it as firestone that the latter will probably continue to be the principal purpose for which it will be used. It is light gray in color, of medium-fine texture, irregularly stratified, evenly bedded, in courses varying in thickness from 2 or 3 inches to 8 inches. Only about 15 feet of the stratum is quarried, and the courses below are probably thicker. The Pocono sandstone in this locality is found also on the top of the synclinal arch of Chestnut ridge, the inclination of the strata

being such as to bring it near the surface at nearly every point on the west side of the mountain. It is quarried about a mile up the side of the mountain, at Turkey's Nest, on the National road, as it has been quarried at the summit of the mountain above, where the stone is said to be superior to that at the other points mentioned, but transportation is so costly from the summit that the quarry there is not operated at present.

At Venango, in Franklin county, the Chenango sandstone, a subdivision of the sub-Carboniferous rocks in Pennsylvania, and known in Warren, McKean, and neighboring counties by the name "sub-Olean", or "flat pebble rock", is quarried for sidewalk paving and general building purposes, and used in Franklin and Oil City. It is gray in color, fine and uniform in texture, evenly and distinctly stratified, evenly bedded, and lying in courses from 1 inch to 30 inches thick. This formation, like the Corry sandstone, was supposed for a time to be the equivalent of the Berea grit in Ohio. In this locality some portions of it somewhat resemble the Amherst "buff" stone in appearance, and other portions have very much the appearance of the Amherst "blue"; and the material is more nearly equal to the famous Ohio stones mentioned than is that of any other quarry in northwestern Pennsylvania. The thicker courses, from 4 to 6 inches in thickness, are used largely for sidewalk paving, and large blocks from the heavier courses can be split into thin slabs by means of wedges. These quarries are located in the right bank of the Allegheny river.

On the opposite side, about one mile back from the river, is a quarry which has been worked quite extensively in the past for paving stone. The layers vary in thickness from 1 inch to 6 inches, and the stone is very micaceous and tough. The stratum of quarry rock in all these quarries is about 15 feet in thickness. The amount of stripping rapidly increases as work is carried farther into the banks.

The Chenango sandstone is also quarried at Titusville, Crawford county, for local use in bridges and foundations. It is here gray in color, massive, coarse in texture, evenly bedded, and in thick layers. The rock from this stratum is used more than any other for building purposes in Crawford county. It is usually colored with peroxide of iron, nodules of which frequently occur from a quarter of an inch to 2 inches in diameter; the color is not uniform, though seldom disagreeable to the eye. The texture differs but little from that of the stone obtained from the conglomerate measures above, except that it is usually more uniform. The rock in most localities very much resembles the Waverly conglomerate of Ohio, and if the following correlation can be sustained the two formations are identical:

CARBONIFEROUS CONGLOMERATE.

Crawford County, Pennsylvania.		Ohio.
Chenango group:		Cuyahoga shale:
Shales	1 = 1.	Shales.
Chenango sandstone	2 = 2.	Waverly conglomerate.
Meadville group	3 = 3.	Shales.
Sharpsville flags	4 = 4.	Buena Vista stone.
Orangeville blue slate	5 = 5.	Berea shale.
Corry sandstone	6.	Berea grit.

But so far as the economic value of these different formations is concerned their identification is of little consequence. The highly valuable deposit of Berea grit in northern Ohio becomes an almost worthless rock within 100 miles east of where it has its maximum development. The Chenango sandstone is usually an ordinary coarse-grained rock, but near Franklin, Venango county, Pennsylvania, it is a uniform, fine-grained sandstone, and is perhaps the most valuable sandstone deposit in western Pennsylvania.

The Sharon conglomerate, existing over an extensive territory and locally known by various names, as "second mountain sand", and "Ohio," "Garland," and "Olean conglomerate", is in some localities a mere mass of quartz pebbles loosely cemented together, and in texture varies from this to a fine-grained blue-black stone. It is quarried near Greenville, Mercer county.

Carboniferous.—As before stated, the Carboniferous rocks in western Pennsylvania and the isolated tracts of the same area in the anthracite regions of the northeastern part of the state, have thus far produced scarcely anything but sandstones for building purposes, and the general statement may be made that they were quarried only for local use. These sandstones intervene between the different beds of coal in the Coal-Measure formations, and are often of coarse and conglomeratic texture, though occasionally fine and compact. The anthracite region gets its supply of building stone mostly from the Chemung, Catskill, and other Devonian rocks quarried at Meshoppen and Nicholson, Wyoming county, and at various places in the mountains extending through the region, and the Carboniferous sandstones are but little drawn upon.

At Shickshinny, Luzerne county, on the Bloomsburg division of the Delaware, Lackawanna, and Western railroad, there is a quarry of sandstone of Carboniferous age quarried chiefly for bridge-building and other railroad work on the line of railroad above mentioned. It is a dark gray sandstone of medium texture, evenly and distinctly stratified, evenly bedded, the layers at the top being 2 inches thick, and at a depth of 100 feet 4 to 6 feet thick. The top stone is used for sidewalks at Wilkesbarre and other towns along the banks of the Susquehanna river, and at Danville, Scranton, and Lancaster. The jail at Danville is built of this stone, and also the side walls of the Bloomsburg jail.

Progressing northward and westward from the anthracite region we come to the Carboniferous rocks in Tioga county. At Antrim, in that county, they are quarried for bridge work and general building purposes, and are used chiefly at Corning, New York. An Episcopal church at Antrim, and a court-house at Wellsboro' are built of this stone. It is light gray, massive, and coarse in texture, evenly bedded, and in thick courses. Much of the material obtained here is almost a purely white sandstone; it is a strong and durable rock, and holds its color well. It presents the best appearance when used in connection with a dark-colored stone, as is well shown in one of the county buildings at Wellsboro', the white sandstone structure being trimmed with white Medina sandstone. It works rather hard under the chisel, and its use is thereby greatly limited. There are indications, however, that if the excavation were carried farther into the bank a softer material would be obtained where it has not been so thoroughly drained; or, in the language of the quarrymen, "where it still contains the sap."

Near Somerset, in Somerset county, there is a flag-stone quarried and used locally for sidewalk paving. It is gray in color, of medium texture, irregularly stratified, very evenly bedded in thin layers, and but little jointed. The total thickness of the ledge is not exposed; it is quarried to a depth of 6 feet only, coming out in blocks varying in thickness from 2 or 3 to 10 inches, the average being from 4 to 6 inches. The general shape of natural blocks is exceedingly regular, presenting, however, an apparently ripple-marked surface. The flags are very hard and would be difficult to dress to a smooth surface, but they resist foot-wear exceedingly well.

At Johnstown, in Cambria county, the Mahoning sandstone, at the top of the Lower Productive Coal Measures, is quarried for general building purposes and used locally. It is dark gray, massive, medium, but uniform texture. The stratum of quarry rock is about 20 feet in thickness, the courses varying in thickness from 8 to 32 inches; there being one 32-inch course near the middle of the stratum. This is the firmest and most uniform in texture, and the most durable material for steps, for which purpose it is largely used. There are thin beds of ferruginous, shaly material between some of the layers. Sometimes this ferruginous material amounts to a thin layer of rich, compact iron ore. The stone itself is ferruginous, and when freshly quarried presents a compact, bluish appearance, flecked through with minute spots of peroxide of iron; and when exposed for a time it changes to a rough reddish-brown color to a depth of 5 or 6 inches. There is a layer about 4 feet in thickness about the center of the ledge. It is so ferruginous as to render it inapplicable to building purposes.

The Homewood sandstone (which is the uppermost of the three subdivisions of the Pottsville conglomerate formation, No. XII, underlying the Coal Measures) of the Pennsylvania geological reports is quarried for bridge construction at Iowa station, Jefferson county, on the Allegheny Valley railroad, and used on the low-grade division of that road. It is a gray, massive, coarse stone, evenly bedded, and in thick courses. Ordinary stone for foundations, bridge abutments, and work of that class can be obtained almost everywhere along this line of railroad from Driftwood to Red Bank; the best perhaps is found in the immediate vicinity of Brookville. It has been used in this town extensively, but only detached blocks have been quarried. The railroad company does not always obtain stone in the same locality, but moves from place to place according to convenience.

At Freeport, Armstrong county, the Mahoning sandstone is quarried for bases and steps, and used along the line of the Pennsylvania railroad from Allegheny to Tyrone. It is gray and light brown in color, irregularly stratified, coarse texture, unevenly bedded, and in courses of medium thickness. This stratum has a much better development farther north, in Clarion county, and it has been quite extensively quarried near Catfish in that county, and near Logansport, Armstrong county. The stone for the construction of the court-house at Kittanning and that for the construction of the new jail at the same place were obtained near Catfish. The texture of the stone differs but little in these two localities, but the color of the Catfish stone is lighter and more uniform than that of the Logansport stone. At these localities the material is quite free from mica.

About 2 miles north of Penn Junction on the Allegheny Valley railroad the full thickness—20 feet—of the stratum is exposed: here the upper and lower portions are quite micaceous, and the middle portion contains very little mica. At the Freeport quarry mica scales are found in abundance from the top to the bottom of the stratum; here the color of some portions of the rock is brown and other portions light bluish or nearly white. The darker portions have the reputation of being quite durable, but the lighter portions are not so. The stone from Catfish and Logansport wears away rapidly when used for steps and door sills, but lasts quite well when merely subjected to atmospheric action. It is easily broken by concussion, but is capable of withstanding considerable pressure.

A quarry near Cowanshannock, a few miles north of Kittanning, has been worked quite extensively from time to time. From this and the Catfish quarries stone has been largely shipped to Allegheny and Pittsburgh.

Mahoning sandstone is quarried at Lucesco, the junction of the Allegheny Valley and West Pennsylvania railroads, on the Allegheny river, in Westmoreland county, and used chiefly for cellar walls and foundations for manufacturing establishments at Pittsburgh. It is employed to some extent for caps, sills, and other trimmings; it is gray, irregularly stratified, and of medium texture, evenly bedded and in thick courses, though much broken at the outcrop. The total thickness of the ledge of the quarry is 60 feet, with indications that it will be found thicker as the quarry progresses in the hill. The hill is so steep at this point that the stripping must increase rapidly unless the ledge sets in more heavily to compensate. The material of the upper 15 feet of the ledge is rather coarse in texture,

with considerable iron in it; that of the lower 20 feet is of a bluish color, close, compact, much finer and more uniform in texture, and proves to be superior to the upper for building purposes. Only the outcrop has as yet been touched, and the ledge presents a broken appearance; but layers 10 feet in thickness are occasionally seen, indicating that as the quarry progresses in the hill the base will not be broken. The Mahoning sandstone is quarried at Derry station, Westmoreland county, on the Pennsylvania railroad, for ordinary building purposes; it is coarse in texture, with signs of stratification distinct, reddish-gray in color; it is used at Greensburgh and other places in Westmoreland county, and at McVeytown. The supply is obtained from large surface bowlders found along the west side of Chestnut Ridge mountain; in this part of the state large surface bowlders of the Mahoning sandstone are found and broken up to obtain material for ordinary building purposes. The stone splits readily into regular blocks, and is variegated in color by alternate different shades of a reddish color parallel with the stratification.

Near Derry station, on the Pennsylvania railroad, another ledge of sandstone belonging to the Upper Productive Coal Measures is quarried chiefly for the construction of coke-ovens by the Loyalhanna Coal and Coke Company. The stone is gray, massive, uniform, medium in texture, and unevenly bedded in courses varying in thickness from 2 or 3 inches to 3 feet. The total thickness of the ledge quarried is about 19 feet. Large, irregular, detached masses from 6 to 8 feet thick, heterogeneous in composition and useless for building purposes, are frequently found embedded in the other stones; these are locally called "nigger heads". The blocks break up with rather irregular fracture, and the stone is not esteemed for any other purpose than the rough work required in the building of coke-ovens, and as these ovens are lined with fire-brick the stone is not subjected to any great degree of heat. The quarry is situated at the foot and on the west side of the anticlinal axis known as Chestnut ridge; and there is considerable dip of the strata toward the northwest, away from the crest of the mountain.

At Greensburgh the sandstone of the Upper Productive Coal-Measure series is quarried to a limited extent for cellar and foundation stone used locally. It is gray, irregularly stratified, of medium texture, and unevenly bedded. The total thickness of the ledge quarried thus far is 15 feet, though in sinking a well close by the whole thickness of the ledge was found to be 37 feet. The layers as observed in the quarry vary from 3 inches to 2 feet in thickness, and a thin vein of coal lies beneath the ledge of stone.

In Webster, near the Monongahela river, in Westmoreland county, a sandstone of the Upper Productive Coal Measures is quarried for paving and used in Pittsburgh. It is gray in color, fine in texture, evenly and distinctly stratified, evenly bedded, and in courses varying from 3 to 16 inches.

At Scottdale, Westmoreland county, on the Southwest Pennsylvania railroad, the sandstone of the Upper Productive Coal-Measure series is quarried for the construction of coke-ovens and house foundations locally. It is of a brownish color, regularly stratified, and evenly bedded in courses varying in thickness from 2 to 8 inches. The total thickness of the ledge of the quarry is 44 feet, which thickness seems to continue regularly throughout. From the hardness of this stone and the ease with which it may be taken out for flagging, it seems better adapted to this purpose than to any other.

At Layton station, Fayette county, on the Baltimore and Ohio railroad, there is a sandstone (between the Upper and Lower Productive Coal Measures, of the Lower Barren Measures quarried and crushed into sand for the manufacture of glass; it has, however, occasionally been used for building purposes. The abutments of the suspension bridge across the Youghiogheny river at Connellsville, and those of the Saint Clair Street bridge at Pittsburgh, were constructed of this stone. It is light gray in color, of coarse texture, irregularly stratified, evenly bedded, and lies in two courses of 10 feet each in thickness, making the total thickness of the ledge 20 feet. The stone increases somewhat in hardness from top to bottom. This material seems very well adapted to all ordinary building purposes, but it serves so well for glass-sand that so far it has been found more profitable to quarry it for that purpose.

Three miles southeast of Connellsville, Fayette county, on the Baltimore and Ohio railroad, is a sandstone of the Lower Productive Coal Measures also quarried for glass-sand. It very much resembles the material at Layton station, and is of such quality that it might be used for local building purposes. It is easily dressed, and exposures of the ledge which have not been disturbed artificially seem to indicate that the stone is durable. There is no regular division here into layers, the rock being usually found in one mass. The quarry is located on the side of the mountain, and the dip of the stratum is about 15 degrees at the point where quarried.

In Connellsville, in the same county, the sandstone of the Barren Measures is quarried for ordinary building purposes and used locally. It is gray, coarse in texture, indistinctly stratified, and evenly bedded in courses varying in thickness from 2 to 3 inches at the top to 12 feet at the bottom of the ledge, the total thickness being about 40 feet. The material of the uppermost 30 feet is of a light brown color, and appears to have a little clay in its composition; it cracks under the effect of water-soaking and freezing, is soft when first quarried, but hardens considerably on exposure. The stone breaks or splits rather easily in almost any direction; wears away rapidly under foot wear, but seems very well adapted for use in caps, sills, and other trimmings. The color of the lower 8 feet of the ledge is bluish, and the material is variable in texture, full of nodules of iron, and holds a good many fossil coal-plants.

Three miles southeast of Uniontown, on the side of the Chestnut Ridge mountain, surface rocks of Mahoning sandstone are found and broken up for ordinary building purposes, used chiefly at Uniontown. The material is gray, coarse in texture, with signs of irregular stratification. The blocks are sometimes as large as 30 by 20 feet

and 12 feet in thickness. When the large rocks are first broken the material is comparatively soft and easily worked; but it becomes hard on exposure to the air, and small fragments that have been long exposed to the atmosphere are extremely hard. This stone seen in houses in Uniontown built fifty or sixty years ago exhibits every evidence of durability.

Near Waynesburgh, Greene county, sandstone of the Upper Barren (above the Upper Productive Coal) Measures is quarried to a limited extent for building purposes and for bases of monuments and other cemetery work, used locally; it is gray, massive, and coarse in texture. Thus far only large surface rocks, some of them 30 feet square and 5 feet in thickness, have been quarried. There seems to be no exposure showing a ledge in place; some of the rocks are on top of the hills. It is uniform in color and texture, works well, may be split horizontally and vertically, and takes carving well for a stone of coarse texture, as raised lettering is sometimes worked on monuments of this material; it stands exposure, becoming harder after leaving the quarry.

Near West Union, Greene county, on the Waynesburgh and Washington road, sandstone of the Upper Barren Measures is quarried for caps, sills, trimmings, and for ordinary building purposes and cemetery work. It is used at Waynesburgh, and the stone-work in the college building at that place is of this material. It is gray in color, massive, of coarse texture, and is obtained by breaking up surface rocks, which are from 10 to 20 feet square and 5 or 6 feet in thickness. These rocks where exposed are covered with a thin, cement-like crust, on which grows a grayish moss. When the crust is broken the stone beneath is found not to be discolored by weather.

Five miles west of Washington court-house, Washington county, on the Baltimore and Ohio railroad, sandstone of the Upper Barren Measures is quarried for caps, sills, curbs, steps, and other building purposes, and used locally. It is gray, coarse in texture, with signs of irregular stratification; the stratum is 20 feet thick, and solid, there being no division in the courses and few joints. The stone-work in the Washington and Jefferson College building at Washington, Pennsylvania, and that in the town hall at the same place, are of this material. The texture and appearance of this stone are uniform throughout the ledge, and the material is among the best found in the vicinity, though the supply of good building stone in this section of the state does not seem to be either abundant or widely distributed.

On the Pittsburgh and Southern railroad, 3 miles east of Washington, Pennsylvania, and on the National pike, about a mile east of that place, there are quarries of sandstone of the Upper Barren Measures, quarried chiefly for foundation stones, caps, sills, and other ordinary building purposes, and used locally. The foundation of Le Moyne's crematory is of this stone. It is gray, coarse in texture, with signs of irregular stratification, uneven bedding, and in courses from 1 foot to 6 feet in thickness, the thin layers often intervening between thicker ones; and in blasting, the thick layers often divide into four or five thin ones.

Near the Pittsburgh, Cincinnati, and Saint Louis railroad, 1½ miles north of Canonsburg, Washington county, sandstone, locally called freestone, of the Upper Barren Measures, is quarried for paving and hearth stones; used also for sills in Washington, Mansfield Valley, and Pittsburgh, Pennsylvania. The stone-work of the Pennsylvania Reform School building, in Washington county, is of this material. It is gray, uniform, of medium fine texture, evenly and distinctly stratified, and evenly bedded. The total thickness of the ledge in this quarry is about 6 feet; the top layer varies from 8 to 20 inches in thickness, then follow two or three layers each about 2 inches, and next the bottom are layers from 8 to 12 inches in thickness, with thinner ones intervening. The bedding is exceedingly even and regular, the surface of the layers being as smooth as if sawed. For paving and hearth stones no dressing is needed except at the edges. The stone splits straight in the direction of the lamination, and vertically, but is hard to dress. It is a favorite in this region for paving and hearth stones.

Near Monongahela City, Washington county, sandstone of the Upper Productive Coal Measures is quarried for ordinary building purposes, and is used chiefly in Pittsburgh and neighboring cities, and in the construction of the Monongahela bridge, Washington county. It is transported by rail and by boat. It is gray, coarse in texture, massive, evenly bedded in courses from 4 to 6 feet thick, and has a good local reputation.

On the Ohio river and the Pittsburgh and Lake Erie railroad, at Stoop's ferry, Allegheny county, the United States government quarries sandstone of the Lower Barren Measures for building purposes, to be used chiefly at Pittsburgh, and to some extent in the construction of bridges at Rochester and Davis Island dam. Transportation is by boat. It is gray, of medium fine texture, massive, evenly bedded, and in thick layers. This quarry has been opened for many years, and worked in a small way, but never to any great extent until the building of the Pittsburgh and Lake Erie railroad, many of the bridge abutments and culverts of which are built of this stone. A house standing near this quarry at Stoop's ferry, built of this stone forty two years ago, is still in a good state of preservation.

At Walker's mills, on the Cairo and Saint Louis railroad, 12 miles west of Pittsburgh, Allegheny county, sandstone of the Lower Barren Measures is quarried for railroad-bridge masonry, and used on the divisions of the Pittsburgh, Cincinnati and Saint Louis railroad between Pittsburgh and Columbus, and also on the branches running from Pittsburgh to Washington, Pennsylvania, and Wheeling, West Virginia; it is gray, of medium fine texture, irregularly stratified, and unevenly bedded in courses varying in thickness from 18 inches to 5 feet, except the bottom layer, which is in places 18 feet in thickness; none of them, however, are of a uniform thickness throughout, but vary considerably within short distances. Partings of shale from a few inches to over a foot in thickness often intervene

between the layers of stone. The lower part of the bottom layer is full of nodules of peroxide of iron, often weighing several pounds each. Coal plants, known as calamites, are found in the lower portion of the ledge. These quarries are situated on the same ledge, the Morgantown sandstone of the *Second Geological Survey of Pennsylvania*), as the local quarries in the vicinity of Pittsburgh and Allegheny, and the character and appearance of the stone are the same as those of the stone quarried at the latter place. The total thickness of the ledge is about 80 feet, setting in thicker as the quarries progress in the hill. A thickness of about 30 feet at the top is of a thin, shelly, broken character, suitable for railroad ballast, for which it is extensively used by the Pittsburgh, Cincinnati, and Saint Louis railroad. Beneath this there are 50 feet or more of solid stone, lying in regular layers varying in thickness from 18 inches to 5 feet, except the bottom layer, which is in places 18 feet thick. This sandstone, as well as nearly all of the sandstones in the region immediately surrounding Pittsburgh, has some calcareous matter in its composition, and wherever a face of the ledge of stone has been exposed for a long time it is very much honey-combed into fantastic shapes, apparently by the disappearance of this calcareous matter, leaving the more siliceous portions intact. The stone when first quarried is very sensitive to the action of frost, and quarrymen say it is best to get it out long enough before winter to allow the "sap" to dry out.

At Mansfield Valley, Allegheny county, also on the Pittsburgh, Cincinnati, and Saint Louis railroad, Morgantown sandstone (near the top of the Lower Barren Measures) is quarried for bridge masonry, and its character is the same as that of the stone from the other quarries on the formation in this region.

The Morgantown sandstone is quarried quite extensively in the hills within and near the limits of Pittsburgh and Allegheny, and it is used almost exclusively for cellars, foundations, sewers, and other underground work in those cities and vicinity. While its character is such as to exclude it from other building purposes, it seems to answer quite well for underground work, and supplies nearly all the stone used in the cities named for this class of construction. It is a bluish-gray in color, medium to fine in texture, with signs of irregular stratification, the bedding moderately even, in layers varying in thickness from a few inches at the top to 4 or 5 feet at the bottom of the ledge. Thin partings of shale sometimes rest between the thin layers at the top, especially at the outcrop. The usual thickness of the ledge is about 35 feet, though at Wood's Run quarry and other places in the neighborhood it reaches a thickness of 100 feet. There is considerable calcareous matter in this stone, and in such a form as to make it liable to decomposition, especially in the smoky and acid atmosphere of Pittsburgh, and at present the inspector of buildings forbids its use for any purpose of construction except underground work. It was, however, frequently used in the construction of important buildings at Pittsburgh: the court-house was built of it, and the stone in its walls is decomposing so rapidly that it is probable that within a few years a new building must be provided. The material when first quarried presents a substantial appearance, and it was formerly thought that the immense cliffs of it which were projecting out of the hills everywhere in the vicinity would furnish an inexhaustible supply of building stone of superior quality for all purposes of construction, and many important buildings were constructed of it before the error was discovered.

At Baden, situated on the Pittsburgh, Fort Wayne, and Chicago railroad and on the Ohio river, in Beaver county, sandstone of the Lower Barren Measures is quarried for foundations and other ordinary building purposes, and is used in Pittsburgh, Brownsville, Greensburgh, and vicinity. It was used in the construction of the post office at Pittsburgh. It is gray, massive, coarse in texture, evenly bedded, in three courses, 8 inches, 8 feet, and 7 feet, respectively, and is considerably broken by irregular joints. It was operated for the two years expiring in August, 1880, by the United States government for stone used in the construction of Davis Island dam.

At Kiasola station, on the Pittsburgh and Lake Erie railroad, in Beaver county, sandstone of the Lower Productive Coal Measures is quarried for ordinary building purposes, and is used in Pittsburgh. The bridge masonry and canal locks in the vicinity are constructed of this material. It is gray in color, of coarse texture, massive, and evenly bedded in thick courses.

Near Beaver Falls, Beaver county, on the Pittsburgh, Fort Wayne, and Chicago railroad, 30 miles northwest of Pittsburgh, sandstone of the Lower Productive Coal Measures is quarried for steps, fronts, curbstones, trimmings, monuments and other cemetery work, fences and walls, and is used in Pittsburgh and vicinity. It was used in the construction of Hostetter's stone front on Fourth avenue, Pittsburgh, and in important buildings in that city. It is gray in color, rather coarse in texture, with signs of irregular stratification, is evenly bedded in layers varying from 6 inches to 5 feet in thickness, with thin shale sometimes between. This is a strong and durable stone, and surface blocks which have slipped from the ledge, and which have been exposed for ages, indicate that it stands exposure well. The quarry is on the crest of a hill 300 feet above the Big Beaver, which flows half a mile from its base and discharges into the Ohio 5 miles distant. The following is a slight description of a section of this quarry: The top layer is a material of uniform color, red when quarried, taking its color from the red iron ore immediately overlying the quarry. A thin bed of shale intervening between each two strata facilitates the working of the rock; between the first and second layers are some thin beds varying from 6 inches to a foot in thickness. No. 2 is a very fine, close-grained, white stone, occasionally of a buff or straw color. It is reported to be the best in the quarry, and ranks well with the different stones used in Pittsburgh for building or cemetery purposes. The supply from this bed is not sufficient for the demand. No. 3 is a hard, heavy, fine stone, always brown in color, except along the cleavage, where it is white. No. 4 is usually a straw or buff color, strong and fine in texture. No. 5 is softest,

sawing well, and variegated in color so as to be objectionable for rubble work; intervening is a thin bed of shale of bluish color, under which lies No. 6, resting on a coal bed. No. 6 is blue in color, except the sap coloring, which is buff, penetrating from 1 foot to 2 feet. Nos. 5 and 6 sometimes come together, forming one course. Nos. 3 and 4 sometimes contain "nigger heads" weighing occasionally from 10 to 20 tons. They are blasted out and thrown over the dump. The lower (No. 6) contains fossil coal plants; in the other rocks the fossils are silicified. Between Nos. 1 and 2 there are fossils of *stigmaria* quite perfect and entire, and the joints are frequently filled with stalactites. There is a slight dip from northwest to southeast.

At Homewood, Beaver county, sandstone of the Lower Productive Coal Measures is quarried for ordinary building purposes and bridge construction, and is used chiefly at Pittsburgh. It varies from a gray to a brown in color, is coarse in texture, shows signs of irregular stratification, and is unevenly bedded in thick courses; it ranks among the best building stones in the western part of Pennsylvania.

Near Wampum, Lawrence county, Homewood conglomerate of the Lower Productive Coal Measures is quarried for bridge construction on the Pittsburgh and Lake Erie railroad. It is gray in color, coarse in texture, massive, evenly bedded, and in thick courses. The Homewood sandstone, which is the upper stratum of the Conglomerate Measures, furnishes most of the building stone quarried in Lawrence county. It is usually a coarse-grained, white or grayish-white sandstone, but in some localities it is colored brownish-red by peroxide of iron. Other strata, especially the Conoquenessing sandstone, are quarried now and then to some extent in different localities. The quarries near Wampum are operated by stone-work contractors on different lines of railroad passing through the place.

At Sharon, Mercer county, the Homewood sandstone of the Lower Productive Coal Measures is quarried for bridge construction and foundations; it is gray, massive, and unevenly bedded in layers not usually exceeding 3 feet in thickness. Several members of the group near the lower limits of the Carboniferous rocks, known in the *Second Geological Survey of Pennsylvania* as the Conglomerate Measures, crop out in the vicinity of Sharon. Different strata of sandstone in this series, and the Chenango sandstone in the Lower Conglomerate, have been quarried for building stone in this locality, but none of superior quality has been produced. The stone from the quarries now operated is a hard, coarse-grained sandstone that is seldom dressed; it seems to be quite durable, however, and is perhaps the most economical material to be obtained in Sharon for cellar walls and foundations, and blocks as large as are ordinarily desired for bridge work can be obtained in some of the quarries. Since the Erie and Pittsburgh canal was abandoned its stone locks have furnished a large amount of cheap and usually quite good building stone to the section of country through which the canal passed, and particularly from Newcastle north. Some of the quarries from which stone for these locks was obtained have been worked but little since the building of the locks, though when the supply from these is exhausted some of the quarries will doubtless be worked again. Sandstone can be obtained almost everywhere in Mercer county, but it is not all good building stone; the localities that do furnish good building stone are but a few miles apart. About 40,000 cubic feet of stone have been quarried for the foundation of the new county infirmary at Mercer. The rock was obtained from quarries located within a radius of 4 miles surrounding the town. The Sharon conglomerate is quarried near Greenville and Chenango, in Mercer county, for flagging, and is used locally. It is gray, fine in texture, has signs of even and distinct stratification, and is evenly bedded in layers usually not exceeding 8 inches in thickness. This formation has here a peculiar development; the stratum is about 12 feet in thickness, and not solid as usual, but in courses from 1 inch to 9 and sometimes 12 inches in thickness. The rock is a blue, fine-grained sandstone; in some places where it has been thoroughly drained, and the particles of iron have been thoroughly oxidized, it has a gray or buff color; it is an excellent paving material, and is shipped to various points in western Pennsylvania and eastern Ohio for paving sidewalks, and is used almost exclusively for this purpose in the town of Greenville in the first-named state. Sometimes the heavier courses occur in the upper portion of the stratum; the iron in them has been peroxidized, and the stone is used to quite an extent for lintels and water-tables. The natural blocks are seldom rectangular, and there is considerable material broken off in shaping up the blocks. Most of this stone, however, finds a ready sale for building foundations.

At Stoneboro', Mercer county, the Homewood sandstone (top member of the Pottsville conglomerate) is quarried for foundation and bridge construction. It is gray and light brown in color, coarse in texture, massive, unevenly bedded in layers from 1 foot to 4 feet in thickness, and is used chiefly in the vicinity. The stratum of quarry rock is about 20 feet in thickness; it is very much fissured, and the natural blocks are variously shaped, though easily reduced to any required form.

At Rockwood, near Oil City, Venango county, detached blocks of the Conoquenessing sandstone (the middle member of the Pottsville conglomerate) are quarried for bridge construction. The stone is gray, coarse in texture, massive, evenly bedded, and in thick layers where found in place. In Report 2⁴, *Second Geological Survey of Pennsylvania*, p. 57, Professor White describes a honey-comb rock found in Crawford county, and near Franklin, in Venango county, and thinks the blocks found in these different localities have come from the same bed, possibly the Conoquenessing sandstone. Some of the blocks at Rockwood show that the lower portion of the stratum from which they were detached has the same peculiar structure, and is probably the same bed.

At Garland, Warren county, detached blocks of the Sharon conglomerate (bottom member of the Pottsville conglomerate) are quarried for bridge construction in the vicinity, and on the Pennsylvania and Erie railroad

The stone is gray, coarse in texture, massive, evenly bedded, and in thick courses where found in place. The principal quarries are located about 400 feet above the level of the Pennsylvania and Erie railroad. The stone is lowered from the quarry to the railroad on a small car running on an inclined track; two cars are used, connected by a cable passing around a drum. The stratum from which the blocks are quarried, as detached, caps the hill about 100 feet above the level of the quarry. The blocks referred to vary in size from the smallest to blocks containing several thousand cubic yards. Most of the building stone that has been used in this part of western Pennsylvania was obtained from such blocks, and from long exposure the material from them is almost universally very hard and difficult to dress; but since it can be obtained without stripping, it is cheaper on the whole than the softer material which might be obtained by stripping the stratum from which the blocks are detached. It is also less expensive, because, the blocks being already detached, a part of the usual work of quarrying is saved. It is difficult, however, to obtain a large amount of this kind of stone of uniform color; a more uniform stone can usually be obtained from the undisturbed stratum. This variegated coloring is due probably to the unequal effects of exposure on different portions of the surface blocks in the oxidizing of the iron in the composition of the stone, and to the unequal effects of exposure on other ingredients of the rock.

Other localities worthy of special notice where building stone has been obtained in this vicinity are near Sinnamahoning, in the southeastern part of Cameron county, and near Ridgway, in the western part of Elk county. The amount of capital invested is small, considering the real extent of the business in this part of the state. Most of the stone quarried is taken out by builders and contractors, and is used chiefly for foundations and bridge construction, the only considerations being cheapness and durability. Detached blocks are found almost everywhere in the ridge except in Erie county. As these detached blocks have been exposed to atmospheric action for ages it is seen at a glance whether the material is durable; and if it splits well it is quarried, and is used in localities to which it can be most conveniently transported. The sum paid for the privilege of quarrying is seldom more than 10 cents per cubic yard for any amount.

Near Meadville, Crawford county, the Sharon conglomerate is quarried for general building purposes and is used locally. It is a light gray, coarse sandstone, massive, evenly bedded, and in thick courses. The stratum is about 45 feet in thickness, though only from 20 to 30 feet of the upper portion is suitable for building stone; the lower portion is coarse, and sometimes a mere mass of quartz pebbles. The upper portion or quarry rock is quite uniform in texture; it is light gray in color, is easily broken into rectangular blocks by means of wedges; is soft when first quarried, easily dressed, and is quite strong and durable. The quarries are located in the summit of the hill, about a mile and a half northeast of Meadville, and the highway is down-grade all the way to the town. Quarries have been worked in other localities in the vicinity, producing an equally good building stone, but from none of these localities can the material be transported readily to Meadville. The Chenango sandstone, here a brownish-gray stone, containing numerous concretions of peroxide of iron, might be quarried to an unlimited extent near by. It has been quarried to some extent and used in some of the finest buildings in Meadville.

QUARTZ PORPHYRY.—Mr. A. E. Lehman, Second Pennsylvania geological survey, sent a number of specimens of quartz porphyry from near Fairfield and Graefenburg, Adams county, and from Pine Grove and Laurel Forge, in Cumberland county. These rocks are identified by Dr. T. Sterry Hunt with the orthopelsite porphyries of the Huronian system of Canada; they underlie the Potsdam sandstone of the South mountains, and overlie the Philadelphia gneiss. They are of a purple color, usually indistinctly stratified, and regularly bedded in courses of varying thickness. The structure of the rock is a fine, compact matrix, with distinct crystals disseminated through it; it is well adapted to ornamental work, as it is rich in color, durable, and susceptible of a good polish, and in many places could be obtained in abundant quantities. It has not as yet been quarried for purposes of construction.

SLATE.

The slates of Pennsylvania are used for school slates, for roofing, for mantels, and for flagging, both in foreign countries and in the principal cities of the United States, especially from New York westward. The quarries of roofing slate at East Bangor, Pen Argyl, and near the Wind Gap in Kittanning mountain; at Chapman, in Northampton county, Slatington, Lehigh county; and in fact all the slate quarries in Northampton and Lehigh counties are located on strata of Hudson River age, overlying thin beds of Utica shale, which in turn rest on the Trenton, Chazy, and Calciferous limestones (the magnesian limestone of the great valley, Siluro Cambrian).

The Hudson River slate formation, 5,000 feet thick more or less, makes two-thirds of the floor of the great Lebanon, Cumberland, or Shenandoah valley, as it is variously called in the states through which it extends, the valley being bounded on the north and west by the Blue mountain, and on the south and east by the South mountain. The Hudson River slate formation occupies the valley from its middle line northward and westward to and up the slope of the North mountain, while the Trenton and magnesian limestones occupy the southern and eastern side of the valley to the foot of the South mountain.

The roofing-slate belt is a continuous strip of varying width extending through Lehigh and Northampton counties close to the foot of and parallel with the Blue mountain. It is not, however, of such a character at all points on the formation as to be suitable for roofing slate. The localities where the material is of such character as to be suitable for the purpose are carefully selected. In fact, the roofing-slate quality is characteristic only of certain beds or small groups of beds at various geographical horizons in the great Hudson River slate formation.

From Report D D D of the *Second Geological Survey of Pennsylvania*, which is soon to go to press, and the revise file of which was kindly loaned for use in this report by Professor J. P. Lesley, state geologist of Pennsylvania, we learn that the whole slate belt referred to as Hudson River slate is an irregular hill country, strongly contrasting with the magnesian limestone country, which borders on the south, both in the comparative number and ruggedness of its water-courses; and that with the exception of Scholarie ridge, in Lehigh county, and perhaps Sandstone ridge, north of Hockendaugua, there are no well defined ridges marking the outcrops of harder subdivisions of the great slate formation, so that it is difficult to separate the main belt into subordinate belts. The whole mass is one formation equivalent to the Hudson River slate of the *New York Geological Survey*, excepting that along the southern border Mr. Prime reports occasional traces of Utica black slate immediately overlying the Trenton limestone. The southern border of the slate district is everywhere a one-sided hill or steep descent toward the limestone lands. The whole formation is divisible into an upper and lower mass, the upper being more massively bedded, and therefore supporting more elevated country. Its uppermost beds constitute the southern slope of the Blue mountain, but the large and important roofing-slate quarries are all in the lower subdivision of the formation.

It is further stated that these same slates extend along the north side of the valley, through Berks, Lebanon, Dauphin, Cumberland, and Franklin counties, into Maryland and Virginia. There are no slate quarries open west of the Schuylkill on this formation, but the same slate formation goes on across the state, and the cleavage shown by the outcrops has about the same appearance.

Red slate outcrops through the western part of Berks county, and a careful examination may disclose that some of the outcrops will produce suitable roofing material.

In New Jersey, at the Delaware Water Gap, a thickness of 3,000 feet is assigned to the whole mass. Mr. Prime's measurements along the west bank of the river make it more than 5,000 feet. Mr. Chance's independent measurement at the Water Gap places the roofing-slate quarries at 2,350 feet respectively beneath the Oneida conglomerate, and his estimate of the whole thickness of the Hudson River slate formation is about the same as Mr. Prime's. In Berks and Lebanon counties the total thickness is stated at 6,000 feet.

The following is an approximate estimate of the position of the quarries on the formation, beginning with the highest and going down: First, quarries at Pen Argyl; second, Hindbeck quarries; third, Slatedale; fourth, Steinville; fifth, Slatington; sixth, Bangor.

The "ribbons" in the slate, described by Professor H. D. Rogers, are very thin layers, from a few lines to an inch or two in thickness, traversing the rocks in bands parallel to each other and at various distances, not generally exceeding 2 feet. These ribbons indicate the direction of the dip of the strata, being seams of somewhat different composition from the rest of the mass. Between each two of the ribbons the layer of slate is homogeneous or of uniform texture and composition, but a difference in the quality of the slate on the two sides of one of these thin layers is quite common. When we examine a new surface of the slate, the usual and permanent color of which is dark bluish-gray, the hue of these ribbons is nearly black, but on exposure to the atmosphere they show, after some time, signs of spontaneous decomposition, and display a whitish efflorescence which indicates that this part of the slate contains sulphuret of iron. The ribbons are therefore carefully excluded from the slate when the latter undergoes the operations of cleavage and trimming in preparation for the market. In most of the slate quarries near Bangor, Northampton county, which is the northern end of the slate belt, the slate is tough and possessed of some flexibility, cleaving readily, the proportion of waste being comparatively small. Toward the southern end of the slate district of Lehigh and Northampton counties the texture and quality of the slates are slightly different from those in Northampton county, and a greater proportion is manufactured into school slates, and some is also shipped for sidewalk paving. Most of the large quarries in this district are producing on an average twice the amount of slate produced two or three years back, with but one-third more force of men and machinery, showing that within certain limits a large force is more economical than a small one. This is true of the quarries at Pen Argyl, East Bangor, Slatington, and in fact of the whole district. From 1876 to 1880, the foreign demand was so great that but little attention was paid to home trade, there being in fact scarcely any home trade. Slates were so low in price that foreign merchants could purchase here and ship to England cheaper than they could buy at home; at present the increase in price of slates created by the home demand has stopped shipments to foreign countries altogether.

In Report D D D, *Second Geological Survey of Pennsylvania*, there is a chapter on the slate region of Northampton and Lehigh counties, covering all that part of the great Lebanon and Cumberland valley which lies between the Delaware and the Schuylkill rivers, and between the Blue or Kittatinny mountain on the north and the edge of the limestone on the south; and there are notes describing the individual quarries. We are indebted to this report for some of the measurements and descriptive matter in the following remarks concerning some of the quarries which were in operation during 1880. The details given will aid in obtaining definite ideas as to the quarries themselves and as to the structure of the slate.

The Bangor Union Slate Company's quarry is 250 by 130 feet deep at the deepest place, with from 10 to 20 feet of drift on the surface. The largest bed is 4 feet thick. The synclinal axis which shows in the Bangor quarry also shows in this one, but the plane of the axis dips slightly to the south instead of to the north as in the Bangor. The

quarry is worked by five cable derricks, which supply the material to twenty shanties, *i. e.*, the sheds in which the slate is cut into shape for roofing. The derricks are run by an engine which, working a line of shafts, connects with the cable derricks by conical friction-wheels.

Bry & Short's quarry, 300 yards east of the old Bangor quarry, is 200 by 150 by 60 feet, with a dip of 10 feet north; the cleavage is 20° south, and the largest bed is 4 feet thick. The quarry is worked by cable derricks run by steam-power. The school slates are planed at the quarry.

The Star quarry, 500 feet west of the east Bangor No. 2, is 200 by 200 by 50 feet, and the cleavage is 20° south; it is worked by cable derricks run by steam, and there are also horse-power derricks, beside appliances for cutting roofing slate and circular saws for cutting school slates. The ribbons in this and the other quarries usually indicate the direction of the stratification, which in this slate district is usually not parallel with the cleavage, but crossing it at varying angles. Much of the material is quarried in such shape that it may be worked up for ornamental purposes instead of being split into roofing slates.

In the Bangor Slate Company's quarry there is a synclinal axis passing through the center of it about 70 feet below the surface; the cleavage and the plane of the axis dip 5° to the north. There are 30 feet of drift on the top of the quarry. The largest bed is 9 feet 6 inches thick. The synclinal axis, being the same that shows in the Washington quarry and in the Bangor Union, pitches to the west. The hoisting is done by cable derricks run by steam, but horses and carts are also used.

The north Bangor quarry No. 1 is 200 by 200 by 40 feet at the deepest place. There are 20 feet of drift covering the slate, and 1 foot below the drift the material is of such quality that it serves for roofing slate. Cleavage, 10° south and 30° east; dip, 45° south and 30° east. The two largest beds are 4 feet thick, and there is a bed measuring 10 feet along the cleavage. The series of beds extends all the way across the flooring of the quarry and all of them are under 4 feet each in thickness.

The north Bangor quarry No. 2 is a few hundred feet north of No. 1, and is 150 by 100 by 40 feet deep. The dip is 35° south and 30° east; the cleavage is 15° south and 30° east. The beds that are exposed are mostly small, each under 4 feet in thickness.

Jackson quarry is 300 by 200 by 100 feet deep. It is worked by cable derricks run by double cylinder steam-engines. The slates come out in good-sized blocks, some of them 20 feet long.

The Jory quarry is 400 by 200 by 80 feet deep. It is worked in the center of a synclinal axis; the dip of the rocks is slight in the center of the axis; the plane of the axis is vertical, while the cleavage is horizontal. This is the only quarry in which the cleavage can be seen at right angles or at any considerable angle to the plane of the axis. The beds worked are not large, but the cleavage makes such a slight angle with the bedding that large blocks can be taken out.

The west Bangor quarry at Pen Argyl is 125 by 150 by 40 feet deep. The dimensions of the largest slab quarried were 13 feet long by 4 feet wide by 18 inches thick, but slabs 15 by 6 feet by 12 inches thick might be obtained.

Stephen Jackson & Co.'s quarry is 400 by 200 by 80 feet deep; dip, 28° south; cleavage, horizontal; beds from 12 to 25 feet long along the cleavage.

The Chapman quarry is 500 by 300 by 130 feet deep. Cable derricks run by steam are used in hoisting the slabs out of the quarry preparatory to working them into roofing slates. Splitters here make from two to six squares a day, averaging about four. The hoisting apparatus is very complete: a slab weighing 2 tons is hoisted 150 feet vertically and 300 feet horizontally in about two minutes. There is a factory here for making and planing slabs and other sawed material, the appliances consisting of diamond saws, planers, gig-saws, and smoothing table—the diamond saw, by reciprocating motion, cutting through slate at the rate of an inch in five minutes, making about 50 strokes a minute. The slates are all thinly-bedded, split well, and are tough. The blocks come out of the quarry in large, even pieces, some of them 20 feet long. The usual dimensions are 8 by 10 feet or less.

Frederick Prime, jr., in Report D D, *Second Geological Survey of Pennsylvania*, says substantially of the slates toward the southern end of this slate quarry district, in Lehigh county, at Slatington, White Hall, Slatedale, Lanipoit, and Steinville, that they are distinguished by bluish-gray or black color, cleave readily into thin slabs, and when the cleavage forms a high angle to the bedding and the slates are free from grit and are otherwise of good quality, they are quarried and are excellently adapted for roofing purposes, school slates, blackboards, and other articles of this nature. Owing to the property they possess of cleaving readily the slates are usually observed with the cleavage predominating to such an extent as to obscure and often to entirely conceal their stratification. As a rule their true bedding can only be observed by means of the wavy lines of a slightly different color from the body of the slates, which are constant and persistent in their passage through the cleavage, these lines indicating the stratification. The quarries of the Lehigh and Northampton district in Pennsylvania are distant about 100 miles from the city of New York and 75 miles from Philadelphia. In 1875, according to Professor Silliman, but five quarries were worked in Lehigh county—the Washington, the Franklin, the Trout Brook, the Bangor, and the Douglas.

The North Peach Bottom Slate Company's quarry is in Whitehall township, on the Lehigh Valley railroad, east of Bethlehem. The largest slab which has been moved thus far was 42 by 10 feet by 20 inches thick, and

blocks 40 by 20 feet by 20 inches thick might be loosened. The custom is to reduce the blocks to such size that they may be conveniently hoisted out of the quarry. The form of the natural slabs here is rhomboidal. The slates come out remarkably even and straight; they are 16 feet long, a straight edge touching at nearly every point on a slab of the material. Transportation from the quarry is afforded by means of the Lehigh Valley railroad and Lehigh and Delaware canal. There is but one grade of material quarried, it being all similar in structure and texture. It is reported that roofing slates from this quarry exposed for thirty years are not yet discolored and need no repairs. The slate is sawed, planed, and rubbed by steam-power. The method of draining the quarry is by a siphon consisting of a pipe 14 inches in diameter and 450 feet long. Mr. John Crump, of the North Peach Bottom Slate Company, states that in his examination of the slates in Pennsylvania and Vermont, and those of Wales, in Great Britain, and of the Angiers district on the Loire, France, he found that the material from this quarry ranks very high in respect to size, thickness, and evenness of the slabs that may be quarried and the hardness, toughness, and uniformity of texture of the material, and for its freedom from ribbon or spots, stains, or quartz veins. The dip of the cleavage in this quarry is about 50° northeast to southwest. The main joints are about 50 feet apart, and about 35 feet below the surface soil sound slate commences half an inch thick, increasing in thickness of strata as it descends. At about 45 feet below the surface the beds are 6 inches thick; at 60 feet, 12 inches thick, and at 80 feet, 20 inches thick. This is the greatest depth quarried thus far, and the proprietors believe that the beds will go on increasing in thickness at a like rate to a depth of 200 feet, at which depth they expect a deterioration.

The color of the slate is blue-black. This slate has been much used by the United States government at Albany, New York; New York city; Topeka, Kansas; Austin, Texas, and Saint Louis, Missouri. The Patent Office building at Washington city has tiling on the top floor of the north side from the North Peach Bottom slate quarries. There are also Chapman slates in the flooring of this building.

Henry & Co.'s quarry, near Slatington, produces material for roofing slate, which is at present transported on wagons 5 miles from the quarry to the railroad station on the Lehigh and Susquehanna railroad opposite Slatington. The largest slab that has been quarried was 10 by 4 feet by 6 inches. The form of natural slabs is irregular. The method of drainage is pumping by water- and steam-power; the hoisting is by steam, and the dressing by hand.

Caskie & Emack's quarry is located 1½ miles northeast of Slatington. The form of the natural slab is rectangular; the dimensions of the largest slab quarried is 30 by 8 feet by 20 inches thick. The quarry is drained by means of a pump worked by steam-power; the hoisting is done by steam-power, and mantel stuff is worked by circular saws and iron planers run by steam.

James Hess & Co.'s (Slatington) quarry produces material for roofing and other architectural purposes. The dimensions of the largest slab quarried here are 10 by 18 feet by 6 inches, but slabs 18 by 20 feet by 12 inches might be moved. The product is marketed throughout the United States. The hoisting and pumping are done by steam. This firm has a factory for manufacturing school slates, and one for manufacturing mantel stuff, blackboards, and tiling.

The Penryn quarry, at Slatington, operated by W. H. Seibert, produces roofing slate, school slates, and the material for blackboards for public schools; also hearth-stones, mantel stuff, and register-stones. The peculiarity of some of the material of this quarry is that some of the beds are a shade or two darker and softer in texture than others, and are easily distinguished in the quarry. The dark stone or beds, when used for roofing, discolor when exposed, while beds of lighter shade, which are harder, when made into roofing slates hold their color, and are very durable. Frequently hard and soft beds lie side by side in the ledge.

In the quarry of David Williams, at Slatington, the form of the natural slabs is irregular. The transportation from the quarry is by rail, on the Lehigh Valley, the Berks and Lehigh, and the Lehigh and Schuylkill railroads. The power employed in draining, in hoisting, and dressing mantels and blackboards is steam; the drilling and dressing of roofing and school slates are done by hand.

The Columbia Slate Company's quarry is situated half a mile west of Slatington, on a branch of the Lehigh Valley railroad, from whence the slates are shipped to various states and some exported to foreign countries. The hoisting and draining are done by steam, the drilling and dressing by hand.

At the Franklin quarry, half a mile west of Slatington, there are two different varieties of dark blue roofing slate, but no soft beds of school slates. The form of the natural slabs is rhomboidal.

Griesemer & Brothers' quarry produces roofing slate exclusively. The form of the natural slab is rectangular. The dimensions of the largest slab which has been quarried are 16 by 5 feet by 4 inches, but slabs 22 by 15 feet by 6 inches might be moved. The slate is transported on the Lehigh and Schuylkill railroad.

Keever & Lutz's quarry produces roofing slate, which is marketed in Berks and Lehigh counties, being transported by wagon and by railroad. The form of the natural slabs is irregular. Hoisting is done by steam, the drilling and dressing by hand.

Laurel Hill Slate Company's quarry produces slate for roofing purposes. The form of the natural slab is irregular. Hoisting is done by steam, the drilling and dressing by hand.

The Lock Slate Company's quarry produces slate for roofing, school slates, tiles, platforms, and steps. The form of the natural slabs is irregular. Slabs 27 by 8 feet by 3 feet thick might be moved. A branch of the Lehigh

Valley railroad is built to the quarry. Draining, hoisting, sawing, and planing are done by steam, the drilling and dressing by hand. The machinery consists chiefly of saw beds, planes, and patent machines for dressing roofing and school slates.

Joel Neff's quarry, near Slatington, consists of three openings on the same ledge of slate. The material is quarried for roofing, and is marketed chiefly in the United States, though some is exported. The form of the natural slabs is irregular; size of the largest slab quarried, 500 cubic feet, but a slab of 600 cubic feet might be moved. The draining and hoisting are done by steam, the dressing partly by steam, and the drilling by hand.

Krum & Moser's quarry, formerly known as the Blue Mountain quarry, produces roofing slate exclusively, which is marketed in the middle, western, and northwestern states, and is transported by railroad and canal. The form of the natural slabs is rectangular, and the dimensions of the largest slab that has been quarried were 18 by 5 feet by 18 inches. Hoisting and pumping are done by steam, the drilling and dressing by hand.

The Industrial Slate Company's quarry, west of Slatington, is operated for roofing slate exclusively. The form of natural slabs is rectangular, and the dimensions of the largest slab that has been quarried were 15 by 4 feet by 6 inches. The draining and hoisting are done by horse-power, the drilling and dressing by hand.

PEACH BOTTOM QUARRIES.—The ledge of slate in which the Peach Bottom quarries are situated furnishes the dark blue, indurated clay-slate almost devoid of calcareous material, as it is of Archæan age, and therefore older than any of the calcareous rocks of Pennsylvania. The following is an analysis of Peach Bottom slates, specimen from J. Humphrey & Co.'s quarry, half a mile east of Delta, York county, from Report C C C, *Second Geological Survey of Pennsylvania:*

	Per cent
Silicic acid	55.880
Titanic acid	1.270
Sulphuric acid	0.022
Alumina	21.849
Ferrous oxide	9.034
Manganous oxide	0.586
Cobaltous oxide	Trace.
Lime	0.155
Magnesia	1.495
Soda	0.460
Potash	3.640
Carbon	1.974
Water	3.385
Iron bisulphide	0.051
Total	99.800

The percentage of lime in its composition is small compared with that in many other slates, some of which are quite perceptibly calcareous. The nearest belt of calcareous rocks is the magnesian limestone of Lower Silurian age, to the northwestward. Serpentine rock lies on one side of this slate ridge, and asbestus on the other. The ledge at Peach Bottom is several hundred feet in width, varying somewhat in this respect, however, and extending along on the summit of the low ridge which extends in a northeasterly and southwesterly direction. The slate begins in the southwestern part of Lancaster county, Pennsylvania, crossing the Susquehanna river not far from Mason and Dixon's line, passing through the southeastern part of York county, Pennsylvania, and extending into Harford county, Maryland. At the Susquehanna river, on the Lancaster County side, slate was once quarried. The ledge at this point is quite high and steep, but rapidly lowers in passing into York county. The bed of the Columbia and Port Deposit railroad, which passes here, interferes with the disposition of waste.

A few miles farther to the southwest, at Bangor and Delta, and just across the line in Maryland, what is known as the Peach Bottom slate is at present quarried. In quarrying slate for roofing there is always considerable waste on account of material unsuited to the purpose. The quarrymen select locations where there is likely to be the greatest proportion of workable material, of which they judge by the appearance of the slate which extends to the surface. The cleavage planes in most of the quarries are nearly vertical, and are parallel to the stratification; and in some of the quarries there is a set of joints cutting the cleavage planes at angles varying from about 45° to 60°. A noticeable circumstance is that the joints in these quarries are less numerous to the westward. In some of the quarries there is beautiful slate stock which cannot be readily split for roofing slate, but which answers well for other purposes. The following are a few of the buildings in which Peach Bottom slate has been used for roofing: The building of the Bureau of Engraving and Printing at Washington city; the court-house and post-office at Des Moines, Iowa; the Academy of Fine Arts in Philadelphia, and the Westinghouse Air-Brake Company's building, Allegheny, Pennsylvania. This slate ranks high for strength and durability, is not subject to change in color upon exposure, and is tough and fine and smooth in texture. Old buildings in the neighborhood of the quarries have roofs of it which were put on seventy-five years ago, and show no perceptible change in color. It is practically free from sulphur, iron, and lime, the ingredients which when present cause fading and decomposition of roofing slate by exposure. The slates here are manufactured by breaking up the rock first

by blasting, then by different processes into pieces of suitable shape and size for splitting by hand, using for this purpose thin chisels of steel, after which they are dressed or cut into shape and size by a machine. The common sizes are 12, 14, 16, 18, 20, 22, and 24 inches in length, and four or five different breadths to each length are made. The average thickness of slate here is about fifty-five pieces to the foot. The material is sold by the square superficial area of 100 feet, weighing about 625 pounds. Some architects in making out specifications call for thicker slates than those made for the trade. All the sizes made rank the same as to quality and manufacture. Vol. I. *First Geological Survey of Pennsylvania*, gives a short description of the quarries that were operated on the Peach Bottom slate belt about the year 1850; and also some statistics concerning the amount of material quarried and the value. It is stated that the prices of slate for the six years ending in 1853 ranged between $14 and $17 per ton—that is to say, from about $4 to $6 per square: that slates of the largest size, 24 by 14 inches, were $69 per thousand; those 16 by 8 inches, $22 per thousand; and those 12 by 6 inches, $12 per thousand.

The following description of the slate belt of Peach Bottom, by Professor Henry D. Rogers, is in the *Report of the First Geological Survey of Pennsylvania* for the year 1853:

Slate belt of Peach Bottom.—The next subordinate belt which the section crosses is the slate range of Peach Bottom and Slate point. The rock here is a dark blue, indurated clay-slate, much of which has the structure of roofing slate, extensive quarries of which have long been successfully wrought at the Peach Bottom cliffs on the eastern side of the river, and also at numerous points west of the river, in York county, and in Maryland. The workable slate belt here is about half a mile wide. The slaty cleavage and the bedding appear throughout to be nearly coincident in their dip, which at the quarries is nearly perpendicular a little southward. The quality of the Peach Bottom slates is very good, and their exportation is slowly augmenting. The belt runs northeastward through the Slate hill from the river, a distance of about 2 miles, and southwestward through York county from Slate point, a distance of about 6¼ miles, to the state line. Slate quarries have been opened northeast of the river, along nearly the whole distance mentioned, but never extensively wrought, and in the same detached manner through York county. At Slate hill on the river the slate is quarried in steps or benches, and not in one general breast, though the material is so uniformly pure as to admit of being nearly all wrought. On the east side of the river there are seven quarries near the shore, and four others of smaller size back on the hills, which are at the present time unwrought. On the York County side there is only one quarry at the river, but in the interior of the county there are seventeen more, embraced between a point 2½ miles back and the end of the range 6 miles from the river. The workable slate appears not to extend in Lancaster county northeast of the limit given, but in the other direction there are indications that it is prolonged beyond the distance of the 6 miles named. One of the quarries on the river, Brown's Lower quarry, yields slates which will bear strong stove heat without cracking, and the workmen use flags of it for frying their meat upon; so uniform is the composition of the material, and so diffused and regular the metamorphism, that the original planes of sedimentation or bedding are too indistinct at these river quarries to be discernible. The cleavage-planes, the only visible ones, dip about 80° south to 30° east, and this condition prevails throughout.

GENERAL CONSIDERATIONS.—In a treatise on slate and slate quarrying by D. C. Davies, F. G. S., London, 1880, he assigns causes for the recent rapid increase in the slate trade in Great Britain. He states that the progress made by this trade during the last quarter of a century in that country has been very marked and rapid; and with the exception of slight checks given to it during the civil war in America, the war between Prussia and Denmark, and that between Germany and France, the progress has been continuous; that during the last ten years the price of slates has increased 30 per cent., and that the present state of the trade may be described as one of such great prosperity as to be limited only by the ability to supply the demand, the demand being far in excess of the supply. This increasing prosperity of the slate trade Mr. Davies ascribes to the rapid extension of railways over the country, which places slates within the reach of numbers of inland towns from which, excepting for special purposes, they were virtually excluded on account of the cost of carriage. The inland town of Shrewsbury was, until the extension of the railway system, a tile-roofed town, while Chester, to which access is had by water, has been for generations a slated town. In Shrewsbury and most of the other inland and formerly tile-roofed towns slates have superseded tiles. The fact that slate is so rapidly and steadily superseding other roofing materials is chiefly due to the increased facility for transportation afforded by the railways, and it is plain that the same causes influence the development of the slate industry in the United States. The railways not only afford ready means of transportation from the slate regions to inland cities which were before entirely excluded from the use of slate, but new business centers spring up along the lines of the railways and thus increase the demand for slates.

There have been within the last ten years some singular conditions in the slate trade both in this country and in Great Britain. The demand increased so rapidly in the British islands during the past ten years that it was far in excess of the supply, while in the United States during that time the trade was in its infancy, increasing rapidly, however; but from 1876 to 1880, owing to business depression chiefly, to an almost entire cessation in building enterprise, and to the custom of using the cheapest materials, the demand was not equal to the production of the slate regions of the country, bringing down the prices of slates so low that they were shipped to Great Britain, even selling at a lower rate than the Welsh slates: and considerable foreign trade sprung up in this way. However, as the prices of American slates in England could not rise any higher than the prices of the Welsh slates in that country without stopping the American trade altogether, exportation was unprofitable to the quarrymen. During 1880 the general resumption of business throughout this country created a sudden demand for American slates at home, the prices ran up to almost double the former rates, and the demand far exceeded the supply.

The Welsh and the American slates are quarried from formations of the same age—that is, strata of Cambrian and Lower Silurian age. The quarries in Buckingham county, Virginia, and in the slate regions of Harford county,

Maryland, York county, Pennsylvania, Piscataquis county, Maine, Rutland county, Vermont, and Washington county, New York, are probably of Cambrian age, while the region of Lehigh and Northampton counties, in Pennsylvania, is of the Hudson River division of the Lower Silurian age.

The Welsh slate regions at Festiniog, Portmadoc, Carnarvon, Penrhyn, and other places are from Harlech, and Llanberris, and Trenbech beds of Cambrian age, and the Upper and Lower Llandeilo and the Wenlock strata of Lower Silurian age. A comparison of chemical analyses of the Welsh and American slates aids to determine their relative values as roofing materials. The fact that Welsh slates are shipped to the United States, and at times figure considerably in the American market, and that American slates are exported to Great Britain and Ireland, makes this question one of importance. The following are some analyses of Welsh slates given by Mr. Davies:

ANALYSIS OF ORDINARY WELSH ROOFING SLATE (BLUE).

[Given by Professor Hull (a).]

	Per cent.
Silica	60.50
Alumina	19.70
Iron (protoxide)	7.83
Lime	1.12
Magnesia	2.20
Potash	3.18
Soda	2.20
Water	3.30
Total	100.03

ANALYSIS OF DARK BLUE SLATE FROM LLANGYNOG, NORTH WALES.

[By Mr. D. H. Richards, analytical chemist, of Oswestry.]

Analysis of slate dried at 100 C.:

	Per cent.
Loss on ignition	3.720
Silica	60.150
Protoxide of iron	5.837
Sesquioxide of iron	1.815
Alumina	24.200
Not determined—alkalies, etc	4.278
Total	100.000

ANALYSIS OF THE MATERIAL OF THE GREEN BANDS IN THE BLUISH-PURPLE SLATES OF LLANBERRIS.

[Made at the Royal School of Mines for Mr. George Maw, F. G. S., of Broseley.] (b)

	Per cent.
Silica	66.45
Titanic acid	0.63
Alumina	13.38
Protoxide of iron	1.71
Peroxide of iron	1.41
Protosesquioxide of manganese	0.91
Lime	2.86
Magnesia	6.28
Potash	0.05
Soda	0.90
Carbonic acid	1.30
Combined water	3.90
Hygroscopic water	0.13
Total	99.91

ANALYSIS OF THE PURPLE SLATES OF NANTLLE.

[Given in *Kirwan's Mineralogy*, Vol. 1, p. 210.]

	Per cent.
Silica	0.48
Argillaceous matter	0.26
Magnesia	0.08
Lime	0.04
Iron	0.14
Total	100.00

For analysis of Peach Bottom, Pennsylvania, slate, see page 110.

a Lecture on Slates of Great Britain and Foreign Countries.

b Geological Magazine, 1868, p. 123.

MARYLAND.

[Compiled mainly from notes of Messrs. Huntington, Monroe, and Singleton.]

About one-half the area of the state of Maryland is made up of rocks of the Cretaceous and the Tertiary ages, which in this state furnish no stones of importance for purposes of construction. A line drawn from near Elkton, in the northeast corner of the state, southwesterly through Baltimore to Washington, following nearly the course first of the Philadelphia, Wilmington, and Baltimore railroad and then of the Baltimore and Ohio railroad, would approximately separate the Cretaceous and the Tertiary areas from the Archæan, adjoining them on the northwest. Passing westward from the line described, about the same order of succession of strata as that in Pennsylvania occurs, as follows: The Archæan rocks, furnishing granites, gneisses, serpentines, and slate; next the narrow belt of the Triassic rocks, from which are obtained the Seneca red sandstone and the Potomac breccia marble; the Lower Silurian strata, in which are found the great Magnesian limestone and marbles; the Upper Silurian, Devonian, and in the mountain region near Cumberland, in the northwest corner of the state, the Carboniferous, none of which have as yet furnished much stone for building purposes. A thorough geological survey of this state has never been made.

CRYSTALLINE SILICEOUS ROCKS.

At Port Deposit, Cecil county, near the mouth of the Susquehanna river, a gray biotite gneiss is extensively quarried, and is used chiefly for heavy masonry, such as bridge construction, docks, harbor improvements, and general purposes of construction. It has been much used by the United States government in public works. Among the structures in which this stone has been used are the Susquehanna bridge at Havre de Grace; the Girard Avenue, Fairmount, South Street, and other bridges in Philadelphia, and the principal bridges in Baltimore; Haverford college, Maryland, Taylor college, Bryn Mawr, the depot building of the Philadelphia, Wilmington, and Baltimore railroad, and Saint Dominick's church, in Washington city. There are several churches in Port Deposit built of stone from these quarries, which show that buildings constructed entirely of this material make a very pleasing appearance. The material is of a dark gray color, rather coarse in texture, and very distinctly laminated. The principal set of joints in these quarries has an inclination of about 60°; but a short distance farther up the Susquehanna river these joints become vertical, or nearly so. A notable circumstance connected with the quarries here is that the planes in which the mica is arranged are vertical.

The gneiss which is exposed in the vicinity of Baltimore is the principal resource of that city for ordinary foundations and the rougher sort of stone-work; it is chiefly of gray color, occasionally greenish-gray. The strata are tilted at various angles and the jointing is irregular. Blocks of any size desired may be obtained. Among the buildings in the construction of which this material was used are the United States court-house and the jail in Baltimore; but that used in the United States court-house may perhaps properly be called a granite, as it is very indistinctly laminated. The quarry from which it was taken is at Granite post-office, in Baltimore county, and the material from the same quarry has been shipped to Cincinnati and to Chicago. It is here gray in color, with a slight pinkish tint.

At a quarry of the same material half a mile from this point the whole mass has weathered, leaving immense bowlders, but in the immediate vicinity the general decay is less than is usual in this section; however, there is a noticeable decay along the natural joints, and in this respect it resembles more the gneisses which are quarried farther to the northward on this formation. On one side of the quarry at Granite post-office there is a large mass of mica schist, which differs considerably from the prevailing stone in the quarry. The material nearer to Baltimore is more decidedly gneissoid, and is used more largely in that city for the purposes before mentioned. This stone is what is usually known as the blue gneiss or mica schist of the Atlantic coast, and there are exposures of it at nearly every point along the line approximately parallel to the coast-line and at the junction of the Tertiary and the Archæan rocks. It is the same that is used in Philadelphia, Baltimore, and Washington for the ruder purposes of construction, and varies in character from the different kinds of gneiss to a mica schist. The most noted granite quarries in Maryland are located near Woodstock, Howard county; the quarries, however, being in Baltimore county. A gray biotite granite, sometimes having a pinkish tint, is here extensively quarried for general building purposes and for monumental work, and is shipped chiefly to Baltimore, Washington, and the west. Among the buildings in the construction of which it has been used are those of the Bureau of Engraving and Printing and the National Museum, Washington, District of Columbia; the soldiers' monument, Winchester, Virginia, and the safe-deposit building in the office of the Baltimore and Ohio Railroad Company, Baltimore. This stone varies from an indistinctly laminated to a massive rock, is a good, safe stone to work, and takes a good polish. The strata are tilted at various angles and the jointing is irregular. Blocks of any desired size may be obtained. In one of the quarries the material lies in the shape of bowlders—a condition which has been brought about by the weathering of the rock. As no glacial action has ever been brought to bear on the strata in this section of the country to remove the weathered portions, the rock is often found covered with a considerable depth of decomposed material.

Near Ellicott City, on the east side of the Patapsco, a biotite gneiss is quarried for curbstones, steps, and for general building purposes, and is shipped to Baltimore and Washington. It was used to some extent in the cathedral in Baltimore. The quarries are in Baltimore county, but Ellicott City, the post-office of this region, is in Howard county. Some of the rock in this vicinity is porphyritic and contains crystals of feldspar an inch and a half or more in length, but they are irregularly distributed through the mass; yet there are places where blocks of some

size can be obtained in which the feldspar crystals are quite regular, in which cases the stone is of uniform and handsome appearance. Much of the rock from these quarries has been used in Baltimore and along the Baltimore and Ohio railroad. For 15 miles west of Relay station, on this road, many of the houses are built of this stone; in all, there are about 100 buildings constructed of it, and Professor Huntington reports that he knows of no other place in the country where there are so many stone buildings in an area of the same size. Among the other places from which specimens of gneiss and granite have been obtained are the Relay House, the Winans estate at the mouth of Gwynn's falls, Orange Grove station, and Ilchester, on the Baltimore and Ohio railroad.

With regard to texture the material here varies very much, some of it being quite fine and some coarse. The general dip of the rock is north-northeast.

At the mouth of Gwynn's falls some of the rock is properly a granite, but passes into a gneiss on one hand and a binary micaceous granite on the other, presenting a width of 30 feet on the front. The general dip is about 45° north-northwest. Professor P. H. Uhler regards all the granites of this region as inclosures—that is, entirely surrounded by rocks of a different character—and cites numerous examples to sustain his views; he does not find any intrusive rocks. The strike is north-northeast.

A specimen of granite was forwarded from Montrose post-office, 3 miles east of Rockville, Montgomery county, by Professor Munroe, who reports that the mass of granite here has simply been exposed. It is comparatively easy of access, the location of the exposure being on the hillside, but there is considerable depth of stripping.

Soap-stone exists here also, and was formerly quarried. It comes in direct contact with the granite.

In the Archæan rocks of Maryland is a variety of serpentines, some specimens of which in the census collection in the National Museum have been polished, and present the most brilliant green appearance.

Near Dublin, Harford county, 32 miles northeast of Baltimore and 62 miles southwest of Philadelphia, a compact and massive green serpentine (sometimes called "precious serpentine") is obtained. This material is fine in texture, of great hardness and tenacity, of a beautiful green color, and is susceptible of a fine and brilliant polish. It is a late discovery, and the quarries are not yet fully developed, but blocks that will dress to the size of 5 by 4 by 2 or 3 feet may now be obtained. The Green Serpentine Marble Company, of Harford county, Maryland, is making extensive preparations for quarrying this material, and Professor F. A. Genth, of the university of Pennsylvania, has published a report on the material. He reports that the supply of serpentine is practically inexhaustible, that it is situated in a most favorable position for quarrying on a large scale, and with an abundant supply of water-power to manufacture it into marketable forms. Professor Genth's description of the mineralogical character of this stone is as follows:

It is a variety of massive serpentine, somewhat resembling williamsite, and shows sometimes a slightly slaty structure. It occurs in various shades of green, from a pale leek-green to a deep blackish green, and, from a small admixture of magnetic iron, more or less clouded; rarely with thin veins of dolomite passing through the mass. It is translucent to semi-transparent; it is exceedingly tough, and its hardness is considerably greater than that of marble, scratching the latter with great facility. The analysis of a deep green translucent variety gave the following results:

	Per cent.
Silicic acid	40.06
Alumina	1.37
Chromic oxide	0.20
Niccolous oxide	0.71
Ferrous oxide	3.43
Manganous oxide	0.09
Magnesia	39.02
Water	12.10
Magnetic iron	3.02
Total	100.00

Hardness (or that of fluor-spar), 4.00; specific gravity, 2.668.

Its green color is due to the oxides of chromium, nickel, and iron present.

In a polished condition it appears to me to be practically almost unalterable, as the polished surfaces do not admit of the absorption of atmospheric agencies which cause the decomposition.

I have above stated that a black, mottled serpentine underlies the green, forming a bed of about 800 feet in thickness. It is not sufficiently developed, but is very conspicuous alongside of Broad creek. It weathers more readily than the green, changing into a white rock spotted with black. The fresh rock, in thin plates, is of a very pale greenish-white color clouded with black. It is softer and less tenacious than the green.

The analysis shows it to be a variety of serpentine, like the green, with an admixture of a larger percentage of magnetic iron. It contains:

Silicic acid	40.39
Alumina	1.01
Chromic oxide	Trace
Niccolous oxide	0.23
Ferrous oxide	0.97
Manganous oxide	Trace
Magnesia	38.32
Water	12.86
Magnetic iron	6.22
Total	100.00

Hardness, 4; specific gravity, 2.669.

It is also susceptible of a good polish, and for some purposes may become a valuable ornamental stone.

About 6 miles north from Baltimore, and near the line of the Northern Central railway, is found a serpentine varying from a light to a dark green in color, but it has been but little quarried as yet.

This rock is very well adapted to be used as ashlar in the walls of churches and other buildings. In a church in Baltimore a small portion of this stone has been used with the serpentine from Brinton's quarry, Chester county, Pennsylvania, similar in appearance in every respect. The area of this rock exposed at this point is about 100 acres. Experience with this material goes to prove that it is durable and stands exposure well, but the surface rock shows considerable disintegration; this, however, is not an argument against the durability of the stone in this region, where, as before stated, no glacial or other denuding influences have removed the product of decomposition. An area of serpentine near Deer Creek, Harford county, is represented by a specimen in the collection.

Fifteen miles northwest of Baltimore, on the Liberty road, a steatite or soap-stone is quarried. It is used in lining furnaces and stoves, for registers, and the manufacture of sinks, ice trays, etc. The color is a greenish-gray. It has defects, which are due to honey-combing occasioned by pyrite cavities.

In the vicinity of Cockeysville and Texas, 16 miles north of Baltimore, on the Northern Central railroad, is a small isolated area of Lower Silurian limestone bounded by rocks of Archæan age, and on this area are located well-known marble quarries. This stone was employed in the construction of Christ church and in the columns and platforms of the city hall, Baltimore, Maryland; the Father Matthew centennial fountain, Fairmount park, Philadelphia; exterior walls of the Washington monument, and the columns and heavy platforms of the Capitol extension at Washington. Blocks 28 by 10 by 3 feet have been quarried, and blocks as large as can be transported by the usual means might be obtained. The stone lies chiefly in large rectangular and nearly horizontal masses. It is usually of a coarsely crystalline texture and of a white or light color. The drilling and sawing are done by steam-power. It is worthy of note that almost all of the marbles of commerce so extensively quarried east of the Alleghanies are from strata of Lower Silurian age, the principal exception being the Snow Flake marble quarried in Archæan strata at Tuckahoe, Westchester county, New York.

At Hagerstown, Washington county, in the great Lower Silurian limestone valley, lying to the west of the South mountain, the limestone is quarried for local use. It is here a magnesian limestone, and specimens analyzed by Mr. Dewey at the National Museum contained alumina and graphite. It was employed in the construction of the Protestant Episcopal and Methodist Episcopal churches in Hagerstown. Professor Charles E. Munroe reports these quarries on a belt locally called Cedar stone, a few hundred feet in width, extending for a distance of several miles, and believed to be peculiar in the fact that the upper layers furnish the most durable stone. There are a number of other localities in the region surrounding Hagerstown and in the same geological horizon as are the Hagerstown quarries. Worthy of mention in this connection is a black limestone found in the Chesapeake and Ohio canal from 4 to 6 miles below Williamsport.

Fogel's quarry, at Four Locks post-office, on the same canal, was worked extensively for stone to be used in the construction of the locks. A variety of light-colored limestone, locally called "Knuckle stone", is found near Benevola post-office; and at the same place there is a quarry of white and variegated marble which was worked for 40 years; it closed in 1858, owing to lack of good facilities for transporting the stone, the quarry being 15 miles from the nearest railroad.

At Keedysville, on the Washington County railroad, a gray magnesian limestone containing black lines is quarried, and is used largely in Hagerstown for steps, underpinnings, and curbs; it resembles the white limestone of Carroll county in the fact that it works easily only in the plane of stratification. It contains a little iron and a silicate.

There are many localities in Maryland where ledges of building stones are but little developed, and from which specimens were collected for the Tenth Census. Among these may be mentioned a siliceous limestone, containing protoxide of iron and a little magnesia, from Liberty pike, Mount Pleasant district, in Frederick county.

Getzendaner's quarry, on the Hagerstown pike, near Frederick, furnishes the "Potomac" or "calico" marble, a calcareous breccia of Triassic age which was quarried at Point of Rocks to obtain the material of which the columns in the old hall of Representatives at the Capitol building, Washington, were constructed. Representative specimens furnished from the Getzendaner quarry show the stone to be here, as in the other points in Maryland and Pennsylvania where it is exposed, a breccia made up of fragments chiefly from the great magnesian limestone to the northwest; its chemical composition being almost the same as the latter.

In a report of the geological survey of Maryland, made in 1833, by Ducatel and Alexander, it is stated that the Potomac breccia marble occurs along the Potomac river, commencing a short distance above the mouth of the Monocacy, reaching nearly to the Point of Rocks, and extending along the valley on the eastern side of the Catoctin mountain to within 2 miles (west) of Fredericktown, at which point it is contiguous to the red sandstone and the blue limestone; and that the formation reappears near Mechanicstown.

Near New Windsor and Union Bridge, in Carroll county, and in the neighboring portions of Frederick county, is found a magnesian limestone which has apparently been subjected to considerable metamorphic action. The signs of stratification are often destroyed, and the color varies from a white with pinkish patches or bands to a pink. A chemical analysis discovers but little variation in the chemical composition of different specimens of this stone; they usually contain much lime, sufficient magnesian carbonate to entitle them to the name "magnesian limestone", a little iron, sometimes in the form of a protoxide, and occasionally a silicate.

SANDSTONE.

There are no large or important sandstone quarries at present operated in Maryland, though, at several localities in the state, sandstone of superior quality for purposes of construction exists in inexhaustible quantities. The most noted quarry of this material is the celebrated Seneca sandstone quarry on the Potomac at the mouth of Seneca creek, 20 miles above Washington city. This material belongs to the Triassic formation described in other portions of this report. The stone was extensively used in the construction of many large public buildings in Washington, including the Smithsonian Institution; the Freedman's Bank building, now the Department of Justice; the Fourteenth Street Lutheran Memorial church; the District jail; and a reference to the remarks on stone construction in the city of Washington will show the other purposes for which it has been used there. There are good facilities for transportation from this quarry to Washington and to all other points along the Chesapeake and Ohio canal.

Specimens of quartzite of Archæan age were collected at Dickerson post-office, Montgomery county, on the Metropolitan branch of the Baltimore and Ohio railroad and the Chesapeake and Ohio canal. It has been used to some extent in the construction of aqueducts, bridges, and furnaces. The aqueduct of the Chesapeake and Ohio canal over the Monocacy river was built of this stone. It is of rather coarse and uniform texture; and its use in the aqueduct shows that it is proof against the action of dampness and freezing, as that structure was built nearly fifty years ago, and there are yet no visible signs of decay of the material. This stone would be suitable for curbs and paving blocks.

At Cumberland, Alleghany county, white sandstone of Medina age is quarried for curbs, steps, and trimmings. It has been used also for bases and cemetery work, and was used in the trimmings of the Protestant Episcopal church and in the construction of the Methodist Episcopal church and the market-house in Cumberland. The material thus far obtained has been very large detached bowlders, found about 7 miles north of Cumberland. The ledge exposed in Wills mountain is about 500 feet in thickness, but this has not yet been quarried, as the material is more readily obtained from the detached rocks before mentioned. Through the narrow valley, about 300 yards wide at the base of this mountain, two railroads run. The stone varies considerably as to its firmness, depending upon the depth in the bed; the upper part is so soft as sometimes to yield to the hand, but the lower part is quite strong and compact.

Professor C. F. Chandler, in a report on the mineral resources of Cumberland, gives the following analysis:

	Per cent.
Silica	98.35
Sesquioxide of iron	0.42
Total	98.77

Another exposure of the same stone is found east of Cumberland, on the Chesapeake and Ohio canal; and there is also a yellow sandstone of Oriskany age, which has been used to a limited extent for building purposes in Cumberland, especially in the construction of the Methodist Episcopal church. It is not quarried at present. The stone varies very much as to firmness; the stratum which is sufficiently firm for building purposes lies at a depth of about 30 feet and is about 18 inches in thickness. When apertures in which water can collect exist in this stone the frost soon disintegrates it, but if the surface is dressed it is quite durable, and buildings in Cumberland in which it has been used, some of them built 15 or 20 years ago, are now in a perfect state of preservation. The stone in this quarry has a dark yellow color. The strike of the strata in this vicinity is a little east of north, following about the course of the mountains. There is but little dip in the strata of either the Medina or the Oriskany sandstones so far as can be seen from the exposure. A dark red sandstone crops out at Frankville and continues to Oakland, in Garrett county. It has been quarried at intervals by the railroad company, for use chiefly in protecting-walls for embankments, and in these structures it seems firm and durable. Tyson gives this material as Potsdam sandstone.

Professor Munroe reports that a white sandstone of excellent quality is quarried to a limited extent at Knowlesburg, and he traced it to the westward from this point as far as Newburg, in West Virginia. He also states that east of Tunnellton it begins to appear above the bituminous coal, which fact proves it to be of Carboniferous age.

SLATE.

The principal slate quarries in Maryland are in the Peach Bottom district, in Harford county, near the state line. The ridge upon which these quarries are situated extends into York county, Pennsylvania, and a number of the quarries are on the Pennsylvania side. The whole is described in the treatise on the building stones of Pennsylvania. The principal quarries both in Maryland and in Pennsylvania are all within a radius of a mile, and produce exactly similar material. For roofing purposes this slate is of a highly superior quality.

On the Baltimore and Ohio railroad, at the village of Ijamsville, Frederick county, there is an exposure of roofing slate which was formerly quarried for this purpose, and several roofs in the vicinity were made during the eighteenth century, and are now in good condition, which speaks well for the quality of the material. These slates are of a beautiful sky-blue color, and are reported not to fade. No roofing slate has been made here since 1873.

VIRGINIA.

[Compiled mainly from notes of Messrs. Huntington and Munroe.]

In Virginia, as in Maryland, the surface rocks of quite a large area of that part of the state lying next the Chesapeake bay and the Atlantic ocean are of Tertiary age and furnish no good building stones. The coarse and durable gray sandstones formerly quarried by the United States government at Aquia creek for the construction of the White House, the old portion of the Capitol, and other public buildings in Washington that were built in the early part of the century, are probably of this age; though, as no complete geological survey of the state has ever been made, the stratigraphical relations of many of its rocks cannot be pronounced upon with certainty. The preliminary reports by Professor W. B. Rogers previous to 1838, and the work done in neighboring states where the conditions of the strata are to some extent analogous, have developed the same general facts concerning the geology of the state. The band of Archæan rocks setting in to the westward of the Tertiary and running approximately parallel with the Appalachian mountains, furnishes granites, gneisses, and slates. The narrow Triassic belt resting upon the Archæan rocks in places supplies the red or brown sandstone which is quarried extensively at Manassas, and the diabase or trap quarried near Catlett station, Fauquier county, and near Leesburg, Loudoun county.

The Triassic sandstone extensively quarried for building purposes at Manassas bears a strong resemblance to the Seneca sandstone at the mouth of Seneca creek in Maryland, it being of the same horizon. The location of the Manassas quarry is near the top of a slight eminence. The strata here are nearly horizontal; there is, however, a slight dip to the south. Only the upper portion of the ledge to the depth of about 20 feet has as yet been quarried. The courses are of various thicknesses up to 6 feet, but the usual thickness is from 5 to 6 feet. Blocks 40 by 20 by 4 feet in thickness have been loosened in the quarry, and a block containing 88 cubic feet was shipped. Between the courses a greenish shale occurs which has a smooth, soapy feel, and when exposed to the atmosphere turns red. The principal markets for this material thus far are Washington, Baltimore, Danville, Virginia, and Charleston, West Virginia. Among the buildings in the construction of which the stone has been used are the District jail, Washington, and the government buildings at Danville, Virginia, and at Charleston, West Virginia. In these structures it was used for trimmings.

The quarries of diabase or trap before mentioned are located on dikes which cut the Triassic formation. That on which the Catlett Station quarry is located is apparently nearly parallel to Cedar Run creek; so far it has been quarried only for paving blocks and for sewer construction in Washington.

The quarry near Leesburg, Loudoun county, is scarcely developed. A fine dwelling was built of this material by C. R. Paxton, near Leesburg. As is usual with diabases, these stones are hard and difficult to work, but work safely and take a good polish.

To the westward of the strata already described the surface rocks are chiefly Silurian, Devonian, and Carboniferous; none of them have as yet furnished much material for building purposes, although a proper exploration would doubtless discover important resources in them. On the Valley railroad, 2 miles northeast of Staunton, Augusta county, there is an argillaceous limestone of Lower Silurian age, locally called slate, which is quarried for slate stock by the Red Bud Slate Company.

A limestone slightly magnesian in character and of Upper Silurian age is quarried chiefly for interior work, furniture, and other ornamental purposes, at Craigsville, Augusta county.

Returning to the Archæan rocks, it may be said that they have thus far been the most important resource for building stone in Virginia. The principal quarries thus far developed are located in Chesterfield and Henrico counties, in the immediate vicinity of Richmond. These quarries have all the advantages of good water transportation, as they are located on the James river, and the material may be shipped by schooner to all points on the Atlantic coast. The stone is a gray biotite granite having the same general characteristics as the gray granite so extensively quarried in the other Atlantic states farther north. The following are notes concerning some of the most important individual quarries of this region:

The quarry of the Richmond Granite Company, on the Richmond and Alleghany railroad, near Richmond, Virginia, produces a massive gray granite used for general building purposes, paving stone, and monumental work, and is shipped more or less to all the states and cities south of New England and as far west as Nebraska. Much of the material is dressed at the quarry, polishing-works being located on the grounds; and at present there is more activity here than at any other quarry in Virginia. A very large quantity of stone has been taken from this quarry, which has been accessible for many years by canal. This, however, has been discontinued, and a railroad now runs to the quarry. Comparing this rock with that of other quarries in the vicinity of Richmond, it appears that the feldspar crystals are larger than those generally seen elsewhere, but they are often irregular in shape and have a brownish color, which shows very distinctly on the polished surfaces. Blocks of any size desired may be obtained.

The Old Dominion granite quarry has furnished material for many important public buildings throughout the country, with principal markets in Richmond, Washington, Norfolk, Lynchburg, and Philadelphia. Among

the prominent structures in which this material has been used are the post-office buildings at Richmond, Philadelphia, and Harrisburg. This quarry is well located for working, as it lies along the Richmond and Danville railroad, and the stone is lifted from the quarry upon the cars ready for shipment. There are as to color two varieties of stone in this quarry; one, a light gray, penetrates the darker after the manner of veins, but there is scarcely any perceptible difference as to texture. There are some peculiarities in regard to the joints in this quarry, and along each joint below the general surface decay is a thin layer of calcite, the lime of which was probably derived from the plagioclase feldspar so abundant in this granite. The waste from the quarrying and cutting of this stone is disposed of by being crushed by a rock-breaker, which is elevated so that the crushed material falls into a car and is transported to various points along the road and used for ballast. Professor J. H. Huntington, who collected the data from this region, expresses a doubt as to whether this granite is of Archæan age, and states that there is evidence that it is much younger than has been generally supposed, and that a study of the granite south of the Old Dominion quarry, along the border of the coal fields, and at Fredericksburg, would probably furnish facts not heretofore known, and might determine the age of these rocks.

At Manchester, in Chesterfield county, is located one of the oldest as well as one of the most important quarries in this section. The surface rock is decayed to a considerable depth, and in some instances bowlders are left in the general decay; but below the point where the general decay ceases the natural joints seem free from discoloration or change, and are nearly horizontal.

In the Tuckahoe district, Henrico county, is a granite quarry recently opened, though in the same locality is situated one of the oldest quarries of this section, and from it the stone for the Washington monument at Richmond was obtained. The quarry, however, is not now operated. The resistance to decay in this rock is very notable, as there are some outcrops that are quite sound on the surface; the jointing is also peculiar, the principal joints conforming to the general slope of the hill on which the quarry is situated. Next to the river the rock is fine grained, but northwest of a quite well-defined line it becomes coarser.

In Amherst and Campbell counties, near Lynchburg, a bluish-gray biotite gneiss is quarried for general building purposes, and is used in Lynchburg, Danville, Richmond, Alleghany, and other cities of this region. It was used in the construction of the Female Orphan Asylum building at Lynchburg. This rock is quite similar to that found in many places along the Atlantic coast, and resembles very much the Potomac gneiss or mica schist in the vicinity of Washington. The quarries in Amherst county are on the left bank of the James river, opposite the city of Lynchburg. The strata are more or less bent and distorted, but in many places they are quite regular, and readily split into layers of from 3 to 6 inches in thickness.

The Fishing Creek quarry is about a mile and a quarter from the station of the Norfolk and Western railroad in Lynchburg. The strata are regular and dip 42° southeast. The material is remarkable in being quite free from iron, and in this respect differs from this stone elsewhere on the Atlantic coast.

A gray, sometimes greenish-gray, biotite granite is quarried in the Namozine district, Dinwiddie county, for general building purposes, and is used chiefly in Petersburg and Norfolk. It was used in the construction of the post-office and custom-house at Petersburg. A notable feature of the granite in the vicinity of Petersburg is that in many places it stands in bold ledges that have for ages defied the disintegrating agencies which have acted with such effect on nearly all the rocks in this latitude. Nowhere else south of the southern limit of the glacial action by which the decayed portions of surface rocks have been removed can granite be seen in such sharp, well-defined ledges as in the vicinity of Petersburg, and there are very few places in regions where the decayed rock has been removed by glacial action that ledges can be found which show on the surface so little sign of decay. The stone from this locality was used at fortress Monroe for the beds for gun carriages, and it is said that where concussion would fracture other stones, this remains intact. It was also used at the Ripraps, at the outlet of Chesapeake bay. The material is for the most part a solid mass, free from joints.

Specimens of granite representing ledges but little or not at all quarried were collected from Verdon depot, Hanover county; and of mica-schist, considerably quarried for foundations and the ruder purposes, generally, in Washington, from near the Chain bridge in Fauquier county, a few miles above Georgetown, on the Potomac river.

SLATE.

In Buckingham, near New Canton and Ore Banks, Buckingham county, a very superior quality of roofing slate is extensively quarried and shipped to the principal cities of Virginia and to Washington, and is quite extensively used as a roofing material in the latter place. It is of a bluish-black color, and has the pearly luster peculiar to the best slates. The following description is by Professor J. L. Campbell:

The fine roofing slates of Buckingham are worthy of special consideration, as well on account of the quality as for the quantity of the material there found. The belt of slate is on Hunt's creek, a branch of Slate river. The quarries extend up this creek for several miles, with a trend practically parallel with Slate river, and at a distance of from 1 mile to 2 miles east of it. The slates are intersected by numerous veins of igneous quartz, not unlike, in general appearance, the gold-bearing veins; and also by occasional trap dikes, one of which crosses an old opening in the Nicholas quarry. The heat from these igneous rocks has doubtless been a very potent agency in giving the slates that highly indurated, metamorphic condition that renders them so durable, while a uniform lateral pressure acting at right angles to their planes of stratification has given that peculiar structure which results in an easy and regular cleavage when fully quarried.

Some of these quarries have been worked for more than half a century. The principal ones are all that need be named. What is known locally as "Perrow's big quarry", owned by Mr. J. M. Norvell and other persons at Bremo, is on Hunt's creek, 1 mile east of Slate

river and 2 miles from the James. A vast quantity of slate has been taken from this quarry, but when we visited the place it was suspended on account of some conflict of claims. The Nicholas quarry, a little farther up the creek, is worked on a large scale, and stones shipped from Bremo by the Richmond and Alleghany railroad. Messrs. Edwards and Robertson's quarry, in the same vicinity, is largely opened, very successfully operated, and its products shipped by the same route. The strata, or rather laminæ, of slate in all these quarries are nearly vertical and have a very uniform strike north 25° east, which is about the average bearing of all the strata between Slate and Willis rivers.

At present nearly all the slate from these quarries is split and shaped for roofing purposes, except where special orders are to be filled. Its strength, durability, and uniformity of texture have given it a national reputation. * * *

The same belt of slate appears on the north side of the James, on the Cocke estate, a short distance above Bremo station, but has not been opened to a sufficient depth to test its quality at that point.

Another belt of slate, apparently of the same geological associations and age as the one just described, lies near the southeast base of the Blue ridge, in both Amherst and Bedford counties, cut through by the James river 4 miles below Balcony falls. It is extensively exposed about 2 miles northeast of the river, where a Lynchburg company has opened a quarry that yields a slate of fine appearance and of finer grain than that of the Buckingham quarries. A small opening has also been made on the southwest side of the river, by the Alleghany Coal and Iron Company, sufficient to prove the existence of slate of good quality, and to indicate the presence also of a large quantity. I have subjected samples from this belt to crucial tests, which they bore remarkably well.

There is a number of other points within reach of the railroad at which slate of promising appearance crops out on the surface, but the true character of the material can be determined only by actual openings to such depth as will reach beyond the limits of long-continued weathering.

MARBLE AND LIMESTONE.

Marble and limestone quarries have not thus far been much developed in Virginia, though there are several points where these materials have been quarried to a limited extent for local use. The most extensive and best known quarry of this class of rock in Virginia is at Craigsville, Augusta county, where what is known as "coral marble" is quarried, chiefly for interior work in buildings, and for furniture and ornamental purposes generally. It is shipped to New York, Baltimore, Boston, Cleveland, Chicago, Milwaukee, Cincinnati, Saint Louis, and other cities of the country. In texture it is fine, semi-crystalline, fossiliferous, and of a pinkish-gray color. There is quite an extensive area here of this material of uniform character. Specimens dressed at the National Museum show that it takes a good polish. Specimens of limestone, representing ledges which have thus far been but little quarried, were received from the following places in Virginia:

A magnesian limestone from near the Natural bridge, Rockbridge county, locally called marble, but properly a magnesian limestone, sometimes containing a silicate; a magnesian limestone, locally called marble, from Timberville, Rockingham county, and a dolomite from the same locality; a dolomite, locally called marble, from Madison Run station, Orange county; a stalactite from Luray cave, Page county; and a marble from Greenwich, Rockbridge county.

SOAP-STONE.

Specimens of steatite or soap-stone were received from various points in the state, but this material has not thus far been used for purposes of construction.

NORTH CAROLINA.

The following statements and descriptions are made up from the schedule reports furnished by Professor W. C. Kerr and W. H. Kerr:

The same order of strata occurs in North Carolina, generally speaking, as in Virginia and the South Atlantic states. The Tertiary, Eocene, and other later formations occupy a belt next the sea-coast, and are not important sources of building material. A shell-limestone of Eocene age, used for underpinnings, fences, mill-rocks, and lime, is quarried near New Berne. It seems to be made up entirely of marine shells. This stone can be hewn into shape by axes, but does not stand exposure well.

Material of the same nature is quarried at Rocky Point, Pender county, and has been used to some extent in the breakwater and other harbor improvements at Wilmington. It is transported by flatboats on the Northeast river, and to some extent by rail on the Northwestern railroad. This material is more compact than the New Berne shell-limestone; the rock lies beneath the surface at a depth varying from 1 foot to 6 feet, has a thickness varying from 1 foot to 5 feet, and underlies an area of about 4 square miles. An area of about 100,000 square yards has been quarried over. The rock sometimes overlies a loose, partially-decomposed lime-rock of a foot or two in thickness, and sometimes a bed of marl 2 or 3 feet thick is superimposed. This marl carries from 85 to 90 per cent. of carbonate of lime, and is used as a fertilizer after passing through a pulverizer. Professor W. C. Kerr, state geologist, states that the material withstands considerable crushing weight, and is very serviceable in rough work.

TRIASSIC ROCKS.

A narrow belt of Triassic age extends through the center of the state, and furnishes fine, compact red sandstone of superior quality for building purposes. Professor Kerr, who has collected for the National Museum a representative set of building stones from this state, sent specimens from rocks of this age from the following places: Wadesboro', Anson county; Sanford, Moore county; 3½ miles east of Egypt, Chatham county; near Durham, Durham county.

That quarried near Wadesboro' is used for ordinary building purposes, sills, steps, grindstones, and whetstones. It is of fine, compact, uniform texture. The principal markets are Charlotte, Wilmington, and neighboring places. The color of this stone varies from a dark brown to a brick-red, and occasionally a buff. The Triassic sandstone quarried at Sanford is used chiefly in Raleigh, and may be seen in the Raleigh court-house. This stone lies in nearly horizontal strata, which are from 1 or 2 to 4 or 5 feet in thickness, with a depth beneath the surface varying from 1 foot to many feet. It is worked and can be quarried at small cost, stands exposure well, and is being quite extensively introduced as a building and trimming stone. It is soft when first quarried, but in a week or two becomes quite hard and takes a fine dressing.

The sandstone quarried near Egypt is used for building purposes, and is marketed chiefly in Raleigh. It is a durable, fine, brown sandstone, used to some extent for grindstones during the war, and is locally used as a general building material and in the construction of iron furnaces. The strata have a dip to the south of 12°, and strike east and west. The stone outcrops in the side of a considerable hill, and is worked with little difficulty.

The Triassic sandstone quarried near Durham is chiefly of a pale gray color, though some of it is brown, and of fine to medium texture, occasionally coarse. Among the buildings in the construction of which it was used are the Raleigh Bank building and the dwelling of Mr. Speight. It has been used for 30 years or more in Raleigh and vicinity. It is comparatively easy to work, and is durable.

ARCHÆAN ROCKS.

The Archæan rocks, setting into the westward of this Triassic belt and occupying the whole of the middle and western parts of the state, form one of the most important sources of building stone in North Carolina. They furnish fine gray granite of superior quality at many points. These granites in many cases differ but little from those quarried in the New England states, but have not the advantage of being so near the sea-board as to be accessible by water transportation; they are usually massive, showing scarcely any signs of stratification, but gneiss of good quality for building purposes is abundant. Specimens of granite were forwarded by Professor Kerr from Charlotte and from Davidson College, Mecklenburg county; Lexington, Davidson county; from various points in Alamance county; Louisburg and Cedar Rock, Franklin county; Salisbury, Rowan county; Asheville, Buncombe county; Rockingham, Richmond county; Danbury, Stokes county; Mount Airy, Surry county; Winston, Forsyth county; Concord, Cabarrus county; Garibaldi and Gastonia, Gaston county; Tosneot, Edgecombe county; Greensboro', Guilford county; Mount Mourne and Mooresville, Iredell county; Oxford, Granville county; Warrenton, Warren county; Buckhorn Falls, Harnett county; Shelby, Cleaveland county; red granite from Cotentney creek, near the Weldon railroad, Wilson county; gneiss from near Greensboro' and Jamestown, Guilford county; Henderson, Vance county; Shelby, Cleaveland county; near Louisburg, Franklin county; Henry's station, McDowell county; Morganton, Burke county; Hickory, Caldwell county; Statesville and Mooresville, Iredell county; Northington's ferry, Harnett county; and Raleigh, Wake county.

The granites and gneisses at most of these localities have, so far, only been slightly used for local purposes. The following notes afford some information respecting their nature and availability for building purposes at some of the different localities:

Ten miles northeast of Greensboro', Guilford county, the gneiss shows no observable traces of iron or other material to produce disintegration, and the exposed surface is sound and durable. The blocks lying at the quarry seem nearly as fresh as when first quarried. This quarry was first opened some years before the late war, furnishing good rock for mill-dams in the neighborhood. Subsequently some stone was quarried for other purposes during the war and near its close, but no regular quarrying has been done there since. The material varies from medium fine to rather coarse in texture; it is gray, fairly uniform, works with comparative ease, and splits readily in rectangular blocks and in any desirable thickness. The surface exposure at the opening indicates the presence of an extensive supply of the material. The stratum in which this quarry occurs, or the line of its outcrop, was traced for some distance in a general northeast direction, and in it two or three thin exposures were found, indicating the probable presence of good material in considerable quantity.

Ten miles west of Greensboro' is found a gray, medium-fine to coarse gneiss, used to some extent for railroad work and for ordinary building purposes. The quarry is located about 3 miles north of Friendship, a small station on the line of the Northwestern North Carolina railroad, so that the facilities for transportation are fair.

On the line of the North Carolina railroad, near Lexington, the granite has been quarried to some extent for railroad and local purposes; the material is fairly uniform and of medium-fine to coarse texture, and varies in color from gray to bluish-gray. The facilities for transportation at present are not good. There are other granite ledges in this vicinity, however, which are more accessible, and the facilities for quarrying are favorable.

At the shops of the North Carolina railroad, in Alamance county, granite is found which is above the average in quality both as to durability and the ease with which it can be worked. It is fine, even-grained, and light gray to gray in color. Though no very considerable opening has been made, there are indications of the existence of a considerable quantity of this stone in the vicinity. The stone is much used by residents of the vicinity, and is highly esteemed. Specimens of it may be seen in monuments and bases at Graham, North Carolina, and elsewhere.

Two miles north of the North Carolina Railroad shops the granite underlies a considerable extent of ground, and crops out in such a way as to indicate accessibility and ease of working. The outcrops on the hillsides are very favorably located for quarrying, and present an exception to the general rule in this vicinity, as the strata are not tilted. An examination of the specimens sent from this place by Professor Kerr indicates that the granite beds in this region underlying considerable depth of earth promise to afford a material much better in working qualities, as well as more even in structure, than that commonly found on the surface or at outcropping points.

At Louisburg, Franklin county, a medium-fine, uniform, gray granite is found. It was used in the construction of the jail at Louisburg. The rock comes to the surface in great masses, being bare for many rods and at several points in and near the town.

Four miles south of Salisbury, Rowan county, is found a medium-fine, uniform, gray granite. The rock crops out in a huge ledge called Dunn's mountain, in fact, it constitutes a range of high hills running northeast and southwest, and 300 or 400 feet above the surrounding country. On the summit of Dunn's mountain the rock projects above the surface in huge bowlder-like masses from 15 to 20 feet high, some of them containing hundreds of tons. The process of quarrying is merely the splitting of these masses. Some of these blocks contain minute octohedral crystals of magnetite disseminated through the mass, which may be easily removed from a powdered specimen with a magnet. They do not affect the quality of a stone, and discolor it only for a short time on a dressed surface.

Near Henderson, Vance county, a gray, rather fine grained gneiss of very uniform texture is quarried, chiefly for railroad construction; it was employed in the construction of bridges over Haw and Deep rivers, the foundation of the post-office at Raleigh, and other structures. This material works well and easily, is comparatively hard, very durable, and is much used in the neighboring region.

Seven miles below Asheville, Buncombe county, a granite of fine and uniform texture is quarried for local purposes; it is a light gray in color, is easily wrought, splits readily into any regular form and size, and stone-cutters prefer it to any other rock in the region.

The gneiss near Jamestown, Guilford county, has been employed to some extent for railroad work and local purposes, and was used in the construction of bridge piers at Deep river, on the railroad. It is a fine, even-grained, gray gneissoid granite, and gives strong indications under the hammer of working unusually well. The nearest point on the railroad is 3 miles.

At Mount Airy, Surry county, the granite forms a ridge; it appears either at the surface or a few feet below, and outcrops at short intervals within a radius of 2½ miles of the place. One hill, within a mile of Mount Airy, 120 feet high shows an exposure of about 40 acres of this rock extending from its base to the top. The granite shows no jointage structure, and the hill is to all appearances an unbroken mass. The granite splits readily, is quarried and dressed with great facility in blocks of enormous size, and is of a durable character.

Four miles south of Winston, Forsyth county, the granite is a dark gray in color and splits readily into required shapes. The stone is quite uniform in texture and structure, though the amount of quartz contained varies somewhat in different parts of the quarry. This granite is durable and has been used for ordinary stone-work in the vicinity. It takes a fine polish and looks well when bush-hammered, but as yet there has been no demand for the material in fine construction. There is an inexhaustible supply, and blocks of any required size may be obtained.

Nine miles south of Salisbury, Rowan county, there is a homogeneous, durable, feldspathic granite of a pinkish color which is used for sills, steps, culverts, and like work. The ledge has an extensive surface exposure, and a jointage structure which aids materially in its working. The stone can be readily obtained in blocks of any required size.

Ten miles south of Salisbury a very hard, dark, granitic rock has been quarried chiefly for the rougher purposes of construction, such as streets, curbs, and door and window sills. It contains quite a large percentage of quartz, is compact and durable and is susceptible of good polish, although not so well adapted to ornamental work as are other rocks in the vicinity. There is a cap-rock 4 feet in thickness, which has been chiefly used, as it is apparently unaffected by the weather. This ledge presents several acres of surface exposure.

At Barringer's mill, Rowan county, a very hard quartzose granite, locally called "millstone grit", is considerably used for millstones, and to some extent as a building material. It is found in large exposures 12 miles north of Concord and 11 miles south of Salisbury. This stone is quite homogeneous and uniform as the outcrop is traced north and south from the quarry, and the supply is inexhaustible.

A fine, uniform, gray granite is found 6 miles northeast of Concord, Cabarrus county. On the Mount Pleasant road, in this county, the stone has an exposure where it has been blasted out in grading. It has an outcrop in two directions, that crossing the road having a general direction a little east of north, while the other has a general direction at right angles to this. The second outcrop can be traced for a quarter of a mile. This material, owing to its fine grain and compact structure, is susceptible of a good polish. It is of a light pink color and splits readily into regular shapes.

A coarse-grained porphyritic granite is quarried 3 miles north of Garibaldi, Gaston county, chiefly for trimmings, curbs, bases, and monuments, but it has also been used a great quantity for bridges and other building purposes. There are two outcrops in bluffs 1¼ miles apart, both being very favorably located for quarrying. This is a good, durable granite, works easily, and is susceptible of a good polish. It can be obtained in blocks of any desired size.

At Gastonia, on the Dallas road, in Gaston county, a hard, fine-grained porphyritic granite is quarried to some extent for ordinary building purposes. The ledge forms a hill on the west side of Long creek, 1½ miles from the crossing of the Dallas and Gastonia road. It is hard, compact, takes a fine polish, is a durable stone, well adapted to all ordinary building purposes, and was used in the construction of the court-house in Dallas. Its highly porphyritic structure renders it somewhat difficult to give it a fine dressing, but it splits readily into regular shapes. The supply is inexhaustible, readily accessible, and blocks of any required size may be obtained.

One and a half miles northwest of Shelby, Cleaveland county, there is a fine hornblendic gneiss. It is a very handsome stone, splitting remarkably well in planes parallel to those of its lamination. This rock seems to harden on exposure. The outcrops and surface exposure extend half a mile in length. There is quite a large quantity of stone accessible, but the exposure most favorable for quarrying is in a bluff some 80 feet in height.

At the point where the Wilmington and Weldon railroad crosses Cotentney creek, in Wilson county, a red feldspathic granite, uniform in texture and structure, is found. It works easily, splitting readily, and takes a beautiful polish. This rock has not yet been quarried for general purposes, having only been used for the piers of bridges and other railroad structures. The rock is found outcropping on both sides of the creek, and is traced for a mile or more up stream. At George Barefoot's mills it crops out in a ledge 40 feet above the bed of the creek.

Two and a half miles north of Tosnecot, on the Wilmington and Weldon railroad, in Edgecombe county, a dark gray, rather coarse porphyritic granite of excellent quality is quarried to a considerable extent for general building purposes. It is used chiefly by the Wilmington and Weldon railroad in the construction of bridges, culverts, etc., and there is a railroad into the quarry. The stone is much used in Wilmington for street curbing and general building purposes. It splits readily, but is quite hard. The outcrop can be traced for a quarter of a mile, and the rock can be had in any quantity. There is a quarry of stone differing a little from this in texture at Rocky Mount, 8 miles to the northwest of this point.

Ten miles east of Greensboro', on the line of the North Carolina railroad, in Guilford county, the granite is not now quarried except for occasional local purposes. The stone here is of rather variable quality, but good material was obtained for the large arched culvert over Rock creek, about a mile east of the quarry. The stone is of medium and coarse grain and of fair quality. The outcrop at various points in the neighborhood indicates that better openings than the one mentioned might be found near by, and that a well-developed quarry on this ledge would produce building stone of excellent quality as soon as the surface rock is removed.

The red granite 2 miles southwest of Hillsboro', Orange county, has as yet only been used by the North Carolina Railroad Company. It is a superior and beautiful building stone, and takes a fine polish.

The gneiss near Louisburg, Franklin county, is of a pinkish-gray color, fine in texture, and works well; there is an extensive surface exposure of the rock.

A compact, hard granite, coarse to medium in texture, is quarried locally for foundations at Cedar Rock, 9 miles east of Louisburg. The stone is found in a surface exposure of several acres, and the supply is inexhaustible. The top bed of rock is of a whitish color, while the bed immediately underlying it has a decided red tinge. The stone is very durable.

A fine-grained hornblendic gneiss is found 1 mile east of Henry's station, McDowell county. It has been used chiefly in railroad construction, and the quarry was quite extensively operated during the construction of the Western North Carolina railroad. The stone obtained from it is very compact and hard, and when polished presents a handsome appearance.

The gneiss 2½ miles west of Morganton, Burke county, is fine in texture and works readily, having quite a perfect cleavage in one direction. It outcrops in a bluff which gives a good quarry face.

The granite on the Carolina Central railroad, 3 miles west of Rockingham, Richmond county, is coarse and porphyritic in texture, and has a peculiar olive color unlike any other stone in the state. The rock projects above the surface in bowlder-like masses from 10 to 15 feet high, and extends along the railroad for half a mile. Its principal use thus far has been in railroad construction.

The gneiss 4½ miles northwest of Hickory, on Catawba river, Caldwell county, is a handsome stone, but has as yet only been used for railroad work. It is easily quarried, and the facilities for transportation are good. The stone is fine and compact in texture, and stands exposure well. It has an outcrop in a bluff on the bank of the river which gives a quarry face some 75 feet in height.

A fine, compact, gray granite has been quarried for railroad bridges, and to a limited extent for other purposes of construction, 5 miles south of Statesville, at Poison Springs, a mile west of the Atlantic, Tennessee, and Ohio railroad, in Iredell county. It shows a good exposure and is easily worked. The strata in the quarry have a dip of 20° to the northeast and a strike northwest and southeast.

A mile southeast of Davidson College, in Mecklenburg county, a fine hornblendic granite of excellent quality for building purposes is found. There is but little stripping, and a large amount of good stone might be obtained near the surface.

A beautiful white feldspathic granite has been quarried for local purposes 5 miles southeast of Davidson College and 4 miles east of the Atlantic, Tennessee, and Ohio railroad, in Mecklenburg county. It is of a uniform,

rather coarse texture, and carries a large percentage of biotite, which gives it a spotted appearance. This stone has an extensive surface exposure of about half an acre. It is hard, but splits readily into regular shapes. The ledge has a dip to the northwest of 15°, and strikes northeast and southwest.

The granite at Mount Mourne, Iredell county, is of a coarse porphyritic texture, stands exposure well, and is suited for ordinary building purposes. There is an extensive surface exposure of the rock, and it can be had in any quantity. Although the texture is coarse, the stone is compact and takes a good polish.

A hard, dark-colored hornblendic granite of fine texture is quarried to a limited extent for building purposes, bridges, and culverts, 3 miles east of Mooresville, on the Atlantic, Tennessee, and Ohio railroad, in Iredell county. The rock carries some pyrite, but not enough to affect seriously its weathering qualities. The ledge has a strike north and south, which can be traced by a surface outcrop for three-quarters of a mile.

Three-quarters of a mile from Mooresville, Iredell county, are two varieties of quartzose gneiss, which have a well-marked line of contact. They are like in structure and composition, but differ remarkably in color. These stones work well and are durable. The outcrop occurs in the side of a hill, and can be traced for a quarter of a mile. The materials would take a good polish, and from their texture, composition, and color it may be inferred that they would be invaluable for ornamental as well as for general purposes. The direction of the outcrop is northeast and southwest, and there is a dip of 10° to the northwest.

At Warrenton, Warren county, a white porphyritic granite is much used for local building purposes, and was used in the construction of the jail. The stone stands exposure well; there is a large surface exposed, and the ledge is so situated that quarrying operations could be conducted with comparative ease.

Nine miles southwest of Warrenton there is a ledge of very pretty fine-grained, rather dark gray granite. It has been used locally for monuments, steps, posts, and work of that class. It is used in the construction of the "Annie Lee" monument.

At Northington ferry, 16 miles from Lockville, Harnett county, there are outcrops of fine schistose and slightly calcareous gneiss in the bluff of the river. The material splits very readily along the plane of lamination, but with difficulty in other directions.

A gray porphyritic granite has been quarried at Buckhorn falls, on the Cape Fear river, Harnett county, for the construction of canal locks and dams. There are good facilities for transportation by river and by railroad.

At Raleigh, Wake county, a quarry has been opened in a bare surface exposure and driven to a depth of 40 feet; it has been operated mainly to furnish material for the penitentiary building, but the stone is also used for culverts, flagging, and works of that class in Raleigh. It is a gneiss of fine to medium texture. At another quarry in the vicinity a fine-grained gray gneiss has been quarried for general building purposes for the last 75 years. It was used in the construction of the capitol and to some extent in the penitentiary buildings at Raleigh.

A short distance from the Carolina Central Railroad track, at Charlotte, Mecklenburg county, the leopardite porphyry is found—so called from the peculiar spotted appearance of the rock. It has been used locally for curbs, sills, steps, and other building purposes. There are few joints in the ledge, and blocks of any desired size may be obtained. The joints are so disposed as to give the natural blocks a rhomboidal shape. It takes a fine polish and is a beautiful ornamental stone, but difficult to work.

MARBLE AND LIMESTONE.

Professor Kerr forwarded specimens of marble and limestone, representing ledges of importance as sources of building material, from the following localities: 3½ miles northeast of Murphy, Cherokee county; Valley Town, 19 miles northeast of Murphy; 1½ miles from Red Marble gap, Macon county; Warm Springs, Madison county; and 10 miles north of Marion, McDowell county.

These marbles and limestones are of Archæan age, according to Professor Kerr, excepting the limestone at Warm Springs, which, he states, may be of later age.

Near Murphy two very distinct marbles outcrop together, one white, fine, and changing to somewhat darker color on exposure, while the other is quite dark and somewhat striped. The white rock is somewhat cut up by jointage, while the other has a massive structure and can be readily sawed into blocks of any shape and size. The stone has been worked to some extent, but never sufficiently to procure a good quarry face. The dark marble is close, compact, has a metallic ring, and takes a beautiful polish.

Nineteen miles northeast of Murphy there is a gray marble with white stripes, which is fine and compact in texture and polishes well. No quarrying has been done here, yet blocks of any size can be readily obtained. The strike of the strata is southwest and northeast, the dip 80° east. In the same vicinity a light gray marble of fine and compact texture, and susceptible of a fine polish, can be had in large quantity, having an extensive outcrop in two places; dip 80° east; strike, southwest and northeast.

At still another place in this vicinity two marbles are found outcropping together, one of a smoky-white color, and the other of a dark or variegated color; both are classed high as ornamental stones, and are susceptible of a fine finish.

One and one-half miles below Red Marble gap there is a marble which has a very extensive outcrop. It occurs in the side of the mountain in ledges 150 feet or more in height. In color it is varied, being of a flesh-color, striped with blue, yellow, or both. It is close, fine, and compact in texture, takes a beautiful polish, and can be obtained in blocks of any size. A railroad in course of construction will pass by the base of this cliff, and there is excellent water-power three-quarters of a mile below for sawing. The outcrops of these marbles are on the west bank of the Nantehala river for a distance of 3½ miles, and seem to overlie a coarse slate which dips 60° to the southeast. The direction of the strike of the strata is east by north.

Near Warm Springs, Madison county, the formation which Safford considers the Knox dolomite crosses the French Broad, rising in steep cliffs along the river on both sides to a height of 40 or 50 feet. It is limestone of a gray to light ash color, fine and uniform in texture. It has as yet been but little used, as the region is thinly settled, but it is a good material for ordinary building purposes.

The dolomitic limestone 10 miles north of Marion, McDowell county, has not as yet been much used for purposes of construction, but is well adapted for general building purposes and for ornamental work. The surface rock is much cut by a jointage, but as the stone outcrops in the side of a hill it is easy to reach a depth which will avoid this difficulty. It varies in color from steel-gray to white.

SOAP-STONE.

Specimens of talc or soap-stone representing ledges of importance were forwarded by Professor Kerr from the following points: 7 miles northeast of Murphy, Cherokee county; 4½ miles from Greensboro', Guilford county; Nantehala river, Cherokee county; from near the North Carolina Railroad shops, Alamance county; and from Deep river, Moore county.

It is all of Archæan age, according to Professor Kerr. It has been used to a limited extent for chimneys, fire-places, hearths, lining for furnaces, and cemetery work.

A pure talc is found on the Nantehala river 5 miles below the Red Marble gap, and again 6 miles east of Murphy, on the line of the Georgia and North Carolina railroad. At the last-named place the talc has an outcrop with white marble in a ledge of considerable extent.

At another point on the Nantehala river, in Cherokee county, there is a very pure talc, translucent, in thin plates, and has been much used as a white-earth. Thousands of tons have been hauled to the railroad and shipped to New York, ground and bolted. It is equal to the finest French chalk.

On the Deep river, in Moore county, the soap-stone is very fine grained pyrophillite. The layers are usually less than a foot in thickness; it has been chiefly ground and bolted and used as a white-earth; much of it is also employed for lining furnaces and building hearths and furnaces. It is used locally and shipped to New York in large quantities.

The method of transportation is by boat 15 miles to the Cape Fear and Yadkin Valley railroad.

FLORIDA.

E. A. Smith, in the *American Journal of Science*, April, 1881, gives the following remarks concerning the geology of Florida:

Almost the whole state of Florida, including the middle and western parts of the peninsula, has for its underlying formation the white or orbitoides limestone of Vicksburg (Upper Eocene) age. This is bordered on the east by a stratum of Miocene limestone, and the edge of the whole peninsula, together with the southern part, including the everglades, is of post-Pliocene or recent formation. The keys are of this recent age, and the coral limestones, which have been much used there, are composed of fragments of the same animals as now live in the gulf. The Hawthorne stone is of Eocene age and contains bones, etc., that identify it. These Vicksburg limestones, more or less covered by beds of stratified pebbles, sand, clay, and marl, form the soil of the state.

The orbitoides (Upper Eocene) limestone is not quarried to any considerable extent owing to the small demand for stone of any kind, but it is locally used for chimneys and house pillars in towns in every section of the state; in Gainesville and neighborhood it is much used. This limestone is often simply a mass of shells, and sometimes orbitoides mantelli is the almost exclusive constituent. The Saint Augustine coquina, or shell-limestone, is used to some extent for local building purposes in Florida. A specimen forwarded to the National Museum, by C. M. Terry, was taken from the basement of a house, and was probably quarried a century or more ago. Other specimens recently taken from the quarry are in the collection, and by comparing the two it is seen that the coquina is a durable stone in the climate of Florida, though there is no doubt it would rapidly disintegrate in the more severe climate of the northern states. The quarries are not operated at present; they are located on Anastasia island, about 2 miles from Saint Augustine. The rock lies very near the surface none of the excavations are more than 6 or 8 feet deep. The stone can be cut with an ax, and is taken out in such shape and size as is required for building. The old city of San Augustine was built wholly of this rock; the quarries were evidently opened more than 200 years ago, as there are houses and broken sections of walls which are older than this. Fort Marion is built partly of coquina. This fort as it is at present dates from about the middle of the eighteenth century. There is a large number of houses in the city that were built one hundred years ago.

On entering a house built of the coquina a sense of dampness and a cool, moist, atmosphere is experienced. The rock seems to possess the capacity of receiving and holding the moisture of the atmosphere; for this reason, and because wood and bricks are cheaper, the coquina is not now extensively used for building stone.

There is another material near Saint Augustine which is called the "shell" sandstone; it is formed on the beaches there by the grinding up of the shells by the sand, which is more or less like that found on all our beaches, except that where this material is formed

the shells are more abundant. It is a recent formation and is hardened by the lime in the sea-water, which is doubtless derived from the shells. These shells are almost entirely bivalve or lamellibranchs, and perhaps a few gasteropods. Mr. Rathburn of the Smithsonian Institution says that almost all of them are lamellibranchs.

Another interesting example of this shell-limestone and the manner in which it is formed is given by Professor Hartt in a publication concerning a sandstone on the Brazilian coast, revised by Richard Rathburn, and published in the *American Naturalist* of June, 1879. It is shown that these reefs are composed of analogous material to the Florida coquina, though they contain more siliceous matter. The solidification is mostly confined to the zone which lies just above and below the level of low tide, and the solidified material rests upon an insecure foundation of loose material. The formation is accounted for in the following manner: The waters of the tropical seas are highly charged with calcium bicarbonates; as the tide rises this water is absorbed by the porous sand, and on the retreat of the tide the solution is concentrated by evaporation, aided by the intense heat of the sun, and the solution becomes saturated in the sand both above and below the level of low water. The consolidation is also aided by lime holding solutions which filter through these stones from the land. This hardening of the sandstone takes a long time, as is shown by the circumstance that these beaches which are in the process of formation or disintegration are not hardened.

At Key West coral limestone is quarried, and numerous public and private buildings are erected of it. There are no quarries now worked although the entire island is composed of it, and in fact the whole of southern Florida is a coral reef. This stone has thus far only been of importance for local use.

There are few stone quarries in the state of Florida. At Hawthorne Mr. C. A. Simmons has opened a quarry, the stone of which is said by the state chemist to consist almost entirely of silica, possibly containing 5 or 6 per cent. of lime, and of a quality for glass-making. It contains petrified bones, and the geological age of the formation is Upper Tertiary. The stone has been gotten out for chimneys, sugar furnaces, and millstones, and to a limited extent for building purposes, but has not been shipped, for lack of means of transportation, but chimneys in the neighborhood were built of it thirty years ago. The rock is very soft when first taken out of the earth, but hardens on exposure to the air and sun. The largest stone taken out was a cube with a 34-inch edge, but a cube two or three times that size might be taken. The supply of this material is reported as inexhaustible, and it is sold at the quarry for 28 cents per cubic foot. It can be cut with a hand-saw, and two men can cut out 1,500 bricks of a size 4 by 8 by 16 inches in a day, each piece being equal to eight ordinary bricks. A railroad will soon be built in the neighborhood.

TENNESSEE.

[Compiled mainly from notes of Messrs. Cotton and Gattinger.]

The colored marbles of East Tennessee are widely known and quite extensively used in this country for ornamental purposes. There are several varieties of beautifully-variegated marbles here possessing superior qualities, the ease with which they are dressed giving them an advantage over the colored marbles found in the Lake Champlain region; though these harder marbles are better for tiling and for other uses where the material is subjected to abrasion. The East Tennessee marbles have been used for decorative work in some of the most important buildings in our own country, including the Capitol at Washington.

The following is a list of some of the buildings in which the marble from the quarry of Mr. E. D. Dougherty, near Mooresburg, Hawkins county, may be seen: United States Capitol, United States Treasury, Washington, District of Columbia; state-house, Columbia, South Carolina; Ninth National bank, Park National bank, Seamen's Savings bank, Cisco building, Grand Central hotel, New York city; residence of William G. Fargo, esq., Buffalo, New York; Lutheran church, southwest corner Broad and Arch streets, Second Presbyterian church, the marble residence of George W. Childs, esq., Schenck's building, and Guy's hotel, Philadelphia, Pennsylvania; First National bank, Chicago, Illinois; residence of Mrs. E. W. Boyle, and that of Mr. John M. Mueller, Cincinnati, Ohio. This quarry is the oldest in East Tennessee, having been opened for the purpose of getting ornamental stone for the Capitol building at Washington. The stone has not been used for general construction on account of the high price which it commands for ornamental work, the price per cubic foot at the nearest railroad station being from $2 to $3.

The marble from the quarry of the Knoxville Marble Company is used for both construction and ornamental purposes. This is the most extensive quarry in Tennessee, and the oldest one in the vicinity of Knoxville. It was opened by the United States government to get stone for the construction of the custom-house and post-office buildings at Knoxville, the stone for the outside of the superstructure being bush-hammered and the mantels and other ornamental pieces polished. The floor tiling is made of this stone and Maclure limestone. A considerable quantity of this marble was also used in the state capitol at Albany, New York. The quarry is located at the junction of the French Broad and Holston rivers, and the stone is carried by boat 4 miles to Knoxville. A bush-hammered surface of this marble has a nearly white color, which, on exposure, becomes still whiter. It is susceptible of being highly polished, and when so polished has a pink tinge and shows wavy, dark lines running through it. It is highly esteemed for mantels and table-tops, because it is not easily stained, and it is also quite largely used for cemetery work. Tombstones which have been exposed for thirty years do not show the slightest signs of disintegration or wear. The stone possesses sufficient strength for the heaviest structures.

Messrs. Frierson and Morgan operate two quarries within 2 miles of Knoxville, one of them producing a white marble and the other a pink material known as Knoxville marble. Analyses made of the white marble show it to be an almost pure carbonate of lime. Marble from this quarry was used in the construction of the custom-house at Memphis, and the shaft of the Lee monument at New Orleans is made of it. The amount of this marble which

may here be quarried is practically inexhaustible. The pink-marble quarry shows about the same characteristics as the quarry of the Knoxville Marble Company. The former is located on the northwest side and the latter on the southeast side of what is known as the Knoxville Marble basin. The limestone crops out on the west side of the pink-marble quarry of Messrs. Frierson and Morgan.

Near Chattanooga, Hamilton county, a bluish-black limestone of the Lower Silurian period is quarried for general building purposes, the stone being used chiefly in that city. The quarry is very favorably located for transportation, being on the bank of the river. The rock is broken up by joints, though blocks large enough for ordinary purposes of construction can be obtained. It dresses quite easily, making a cheap as well as durable building material.

The Cincinnati limestone of the Lower Silurian period is quarried for foundations and underpinnings in the vicinity of Nashville; this material is not of very good quality, but it is the most accessible to the Nashville market, and furnishes most of the stone for ordinary construction purposes in the city. The stratum of limestone quarried is only a few feet in thickness, and but a small portion of the stratum is available for building stone. At a quarry known as the Reservoir quarry, now operated by Messrs. Callahan and Welsh, is a layer about 20 feet below the surface and about 7 feet in thickness, which is considered the best of any found in the vicinity of Nashville, and is the stone most used for buildings in that city. Above this layer there are but from 2 to 5 feet in all of stone suitable for building. The waste material is used for macadamizing streets, and some of the limestone is suitable for burning. Most of the stone found in the vicinity of Nashville disintegrates rapidly when set on edge, and is therefore unfit for curbing; this rapid disintegration is also seen where the stone has been set on edge in buildings, but where it is laid on its natural bed it is quite durable; some stone suitable for curbing is, however, obtained from the quarry known as the College Hill and Vanderbilt.

OHIO.

[Compiled mainly from notes of Professor Orton.]

SANDSTONE.

SUB-CARBONIFEROUS.—Those rocks of the sub-Carboniferous period, called the Waverly group in the *Geological Survey of Ohio*, are the most important as to production of building stone in the geological scale of the state. The following shows the arrangement of this formation, according to Professor Orton:

1. Maxville limestone, in patches.
2. Logan group.
3. Cuyahoga shale.
4. Berea shale.
5. Berea grit.
6. Bedford shale.

No. 1 occurs but seldom. No. 2 consists of fine-grained sandstones overlying and alternating with massive conglomerates in central and southern Ohio. Its thickness is about 100 feet. The Waverly conglomerate is a member of this group. No. 3, about 300 feet in thickness, is a blue argillaceous shale in many parts of Ohio, but in many places contains scattered courses of sandstone of great value. In southern Ohio these are concentrated and become very valuable. No. 4 is from 10 to 30 feet in thickness and is the equivalent of the Waverly block shale of southern Ohio. No. 5 is the Berea grit, the great quarry rock of northern Ohio. It is from 10 to 75 feet in thickness and extends in a belt from Williamsfield, in the southeastern corner of Ashtabula county, westward into Erie county, and thence nearly directly southward in Adams county to the Ohio river. This stratum of sandstone, where it has its best development, consists of heavy sheets with often a course at the top of thin broken layers called shell-rock. However, in many localities these thin layers are unbroken, even, and compact, and are quarried extensively for sidewalk paving. No. 6 is from 10 to 100 feet in thickness, and furnishes no building stone except in Cuyahoga county.

The line of outcrop of the Berea grit across the state from north to south is very near the dividing line between the formations of the Carboniferous age on the east, where the building stone is almost exclusively sandstone, and the formations of Devonian and Silurian ages on the west, where it is almost exclusively limestone.

The Waverly group, with its well-marked alternations of shales and sandstones, enters the state from Pennsylvania in its northeastern corner. The northern line of outcrop of the Berea grit in Ashtabula and Trumbull counties is for the most part deeply drift-covered, and in places it has been cut out by valleys of erosion. From Parkman, in the southeast corner of Geauga county, it can be traced in an almost continuous line of outcrop around to the Ohio river. In Parkman township, as far as exposed, it lies in thin, ripple-marked sheets.

In Mesopotamia, Trumbull county, a quarry of some importance is worked by the Mesopotamia Freestone Company, one mile west of the town center. The stone is used for buildings, flagging, bridges, etc., in the immediate neighborhood, and is of excellent quality. The nearest railroad station is 7 miles away. This company has just taken the contract to furnish the trimmings for the blocks now building at Burton, Geauga county. From

this quarry the Berea grit passes northward, and its outcrop may be traced along the line between Geauga and Ashtabula counties to the southeast corner of Lake county, where it turns to the southwest and follows along the line between Lake and Geauga counties into Cuyahoga county.

The Berea grit is quarried at Windsor, in the southeast corner of Ashtabula county. This quarry marks the most northeasterly locality where the Berea grit has any special economic value as a building stone; though even here the stone is much inferior to that to be obtained over quite an extent of country from Berea, Cuyahoga county, westward to Berlin Heights, Erie county. The pyrites and protoxide of iron contained in the stone at Windsor produce bad discoloration on exposure to the weather. As a source of material for heavy masonry this locality is invaluable, as Ashtabula county has no other stone well adapted for this purpose, and the Windsor quarry has furnished a large amount of stone for heavy bridge construction on the railroads and highways in this county. The quarry is located about 6 miles from the nearest station, and has the same disadvantage as the Mesopotamia quarry for shipping stone.

The most important quarry operations in these counties are carried on in Howland township, 3 miles northeast of Warren, Trumbull county. This stone had been known for many years, and was worked in a small way before the present company began operations. The stone is adapted to the special use of flagging on account of the extreme regularity of its beds, its composition, its strength, and its durability. In evenness of bedding it is remarkable among the quarries of the county. Blocks 10 feet square and 1½ inches thick are extracted, which a straight-edge laid upon the surface would touch at every point. Slabs but 1 inch or 2 inches in thickness have such strength that they go without question into general use. Their fine grained composition causes them to wear in a uniform manner, and they always give a good foothold. The only defect in the quarry is that the north and south joints do not run evenly; but, as these joints are so far distant from one another as to preclude the possibility of transportation of the included masses, this defect is of but little moment. In one case a single strip 150 feet long, 5 feet wide, and 3 inches thick was raised in the quarry. The layers, although so very closely packed together, are perfectly distinct, adhering to each other scarcely more than sawed planks in a pile.

All the townships in this neighborhood avail themselves of this extraordinary supply of flagging, and the town of Warren is said to be the best paved town in the state; Mahoning avenue may be mentioned as exhibiting on its western side some of the finest flagging that has ever been laid. It has been sent to distant cities in northern Ohio, western New York, and western Pennsylvania, and examples of it may be seen in Pittsburgh, Mansfield, Hornellsville, Akron, etc. It has been used for general building purposes to a limited extent.

The quarries are drained by ditches with a constant good fall. In the flagging deposit proper there are found from four to seven courses, varying from 1 inch to 6 inches in thickness, the 6-inch course being the best and highest priced. The same general character of the stone holds in the adjacent territory, but is subject to some variation of quality. It is of a light gray color, and is the geological equivalent of the stone which is extracted from the Portsmouth and Buena Vista quarries at the southern extremity of the formation on the Ohio river.

The Cuyahoga shales, in which the Austin flag-stones are found, occupy the highest position in the Waverly group in this county, and in the southwestern corner of the county the conglomerate of the Carboniferous formation makes its appearance in a ledge called the Braceville ridge, which rises to 100 feet above the flat surrounding country, and occupies a part of the four townships of Warren, Newton, Braceville, and Lordstown. It is almost entirely destitute of soil, and its prominent points are conspicuously grooved and striated by glaciers. This rock has been the dependence of several generations for building stone in the surrounding region, but no large quantity has ever been extracted at any one time.

Over a surrounding area of 75 square miles whatever stone is used for foundations, well stones, and bridge stones is mainly taken from this ridge. The quarry operations are mainly carried on in the way of "gouging"—that is, in extracting the stone wherever it can be obtained to the best advantage without reference to future quarry operations. Although no quarries are systematically worked, several are in readiness for operation at any time; and it is safe to say that, in the aggregate, $1,000 worth of stone per year is extracted. The material is a strong and enduring sandstone, containing but few pebbles, and is of especial value since the flat country for many miles around is destitute of stone.

The Berea grit is quarried extensively at Newburgh and at Euclid, in Cuyahoga county. A quarry has been recently opened on the east side of the Cuyahoga river, near Independence, and the stone has also been quarried at East Cleveland. The smaller quarries have not been considered in the tables.

As a flagging material this stone is considered by many to have no equal in northern Ohio. It is now used almost exclusively for paving the sidewalks of Cleveland and in many other northern cities, especially in the state of Michigan. It is a fine-grained, compact sandstone of a very beautiful blue-gray color when first quarried, a circumstance which caused it to be extensively used for the trimmings of buildings, although its exposure to the weather has frequently modified its appearance. It is not considered safe to use this material for building purposes except for foundations and bridges, as it frequently contains iron sulphide, the oxidation of which produces stains; and when it has not this defect the color due to weathering is not so uniform when the face

of the rock is exposed in a wall as when the bed is exposed in a pavement. A greater amount of the sulphide of iron is contained in the stone at Newburgh than in that at Euclid; and it must be added that examples can be cited where the Euclid stone has presented an unmodified appearance after years of exposure in buildings.

The whole stratum of the rock at Euclid is about 20 feet in thickness, and the different sheets are from 2 to 4 feet thick. As a rule the stone is sawed into slabs.

The outcrop of the Berea grit comes from the northeast, and enters the county in Mayfield township. It has no special economic value in the northeastern part of the county, but near Chagrin Falls, in the southeastern part, it lies in thin sheets, and is quarried to some extent for flagging purposes. At Bedford it will not compare favorably with the stone from some of the other localities for purposes of building; but it is especially valuable for manufacturing into grindstones, which command a high price in market. That variety of stone which is applicable for grinding springs is especially in demand. The material is a rather coarse grained and homogeneous sandstone, filled with little brown spots of iron oxide. In some portions of the stratum lenticular nodules of this oxide occur from one inch to several inches in diameter, and render these portions worthless; but as they occur only at certain horizons they are easily separated from the better material.

At Independence a stone possessing more of the characteristics of the Amherst stone is quarried, especially applicable for the manufacture of grindstones, although it is used to a considerable extent as a building stone. The material has been used in the city hall and in some other buildings at Cleveland. These quarries are located in a bluff, the outcrop of stone being about 4 miles long and 1 mile wide, and usually covered by a drift deposit from 1 foot to 5 feet in depth, although in some localities the rock is quite bare.

The Berea grit is at this place only from 30 to 40 feet in thickness, and only the top 10 feet have been extensively quarried, as immediately below this there lies a stratum of worthless rock from 3 to 12 feet in thickness. Below this, good material for grindstones and building stones is obtained. This has been little quarried on account of the cost of drainage and that of removing the worthless rock referred to. Only large grindstones, which are best adapted for dry grinding, are manufactured from this material, and it is said that the stones do not glaze when used for this purpose.

The statistics in the tables scarcely give a correct idea of the magnitude of the industry at Independence, as the rock has been quarried in many localities in this bluff besides those now operated.

At East Cleveland the Berea grit becomes 60 feet in thickness; and although it does not possess all the desirable qualities of the Amherst and Independence stones, the Cleveland architects prefer it for foundations on account of its superior strength and its accessibility. It has not been used for any important superstructures in the city, the more excellent stone, before mentioned, being so readily supplied to this point.

The Brooklyn quarries, which are situated just to the south of Cleveland, produce a material which is of about the same quality as that found in the East Cleveland quarries, but the rock is more broken, and is used mostly for foundations and underpinnings. Its broken character allows it to be easily quarried, but large blocks are not so readily obtained.

The largest sandstone quarry in the county is situated in Berea, where an immense amount of material has been extracted for building purposes and for small grindstones. Nearly 40 acres of the Berea grit have here been quarried out to an average depth of about 40 feet. The stratum is from 65 to 75 feet in thickness, and has been quarried to the bottom in but few places. The individual sheets are from 2 inches to 10 feet in thickness, and usually are very even in their bedding. The rock all lies below drainage level and seems to have been but little, if at all, disturbed since its deposition. Joints very seldom occur. The stone is usually soft in the quarry and is very easily channeled. It is of a blue-gray color and a little darker as a rule than the Amherst "blue-stone". A larger portion of the formation here is of the so-called "split-rock" character than at any other locality where it has as yet been quarried, and this characteristic is also more perfectly developed here than anywhere else.

The material is not so applicable for the manufacture of large grindstones as is that obtained in Lorain county, or at Bedford and Independence in this county. Small grindstones can, however, be manufactured more cheaply at Berea, because the rock can be split into thin slabs of any desired thickness with little or no waste. The manufacture of whetstones is also quite extensive.

These quarries produce building stones of an excellent quality, although great care must be taken in the selection of the material, as some of it contains sulphide of iron in such amount as shortly to disfigure the surfaces, even discoloring a portion of the wall below it. The material is, however, carefully graded in such a manner as to distinguish the good from the bad stone. For bridge-building purposes the Berea stone is considered the best of the sandstones of northern Ohio, since it possesses greater strength. Tests made by J. B. and W. W. Cornell indicated that a 1½-inch cube would withstand a pressure of 15,100 pounds. The Berea stone has been extensively used throughout the whole country, and may be seen in the following: The Merchants' Bank of Canada building, Young Men's Christian Association buildings, and Montreal Telegraph buildings, Montreal, Canada; post office building, Bank of Montreal building, and the Garland & Mutchinson building, Ottawa, Canada; post-office building, London, Canada; post-office building and Bank of Toronto building, Toronto, Canada; court-house building, Hamilton, Canada; Senator Fessenden's monument; Methodist Episcopal church, Brookline, Massachusetts; New York Clipper buildings, block corner Cliff and Fulton streets, a figure of Christ 10 feet high, and Church of the

Transfiguration, New York city; Berea hall, Brooklyn, New York; court-house, Camden, New Jersey; Normal school, Saint Agatha's church, and Saint Luke's Episcopal church, Philadelphia, Pennsylvania; United States custom-house and post-office, Dover, Delaware; Young Men's Christian Association buildings, Normal School buildings, and Traders' National bank, Baltimore, Maryland; Baltimore and Potomac Railroad depot, *National Republican* newspaper building, British minister's residence, and Lewis Johnson & Co.'s Bank building, Washington city; court-house, Napoleon, Ohio; court-house, Marysville, Ohio; Exchange building, Bronson's block, and Madison hotel, Toledo, Ohio; court-house, Sidney, Ohio; Beckman's building, Cleveland, Ohio; court-house, Winchester, Indiana; court-house, Crawfordsville, Indiana; Masonic temple, Indianapolis, Indiana; court-house, Wabash, Indiana; court-house, Noblesville, Indiana; the Ogden block, Dickey block, and McCormick block, Chicago, Illinois; United States custom-house and post-office, Port Huron, Michigan; court-house, Menomonee, Wisconsin; asylum for the insane, Oshkosh, Wisconsin; Cleveland viaduct, representing bridges.

Three miles west of Berea a large quarry is worked, and in the immediate neighborhood three other quarries are situated, which have not been tabulated here because they produce but very little building stone, and the material is almost exclusively manufactured into heavy grindstones. The total value of the grindstones produced from the four quarries was over $10,000 during the census year. Good building stone could not be advantageously extracted, as the rock is very much broken up. Never more than 12 and usually not more than 7 feet of the rock are quarried, for below this the rock is more broken, and is called "shell-rock". The waste products of the quarries are sold for a mere nominal price for foundations and underpinnings. As the rock lies above drainage it is a very desirable material for trimmings on account of the permanency of its color. The grindstones sell for a little above the average price.

Stone quarried at West View is considered equivalent to the Amherst stone.

In addition to the large quarries mentioned the Berea grit is quarried in a small way to satisfy the local demand. Cuyahoga county forms one of the most important quarry districts in the United States.

Extracting and dressing the Berea grit is the chief industry in Erie and Lorain counties. The material produced from this and the adjoining regions, under the name of the Amherst building stone, is the most highly esteemed of any in the state, and it has been extensively shipped to Canada. There are large areas of good stone near the surface, away from railroad transportation, which have not been opened. Quite a variety of stones, as regards structure, can be furnished from this formation, increasing the number of uses to which it may be applied.

The Amherst quarries in Lorain county are located in a series of ledges which were once the shore-cliffs of lake Erie. The elevated position of these stones is a very great advantage, since the light and uniform color seems due to the fact that this elevation produces a free drainage, and the stones have been traversed by atmospheric waters to such a degree that all processes of oxidation which are possible have been nearly completed. The elevation also facilitates the extraction. Spur-tracks from the Lake Shore and Michigan Southern railroad pass through most of these quarries and supply means of transportation, and the C. and F. V. railroad furnishes means of access to those quarries not in direct communication with the above road.

The Berea grit at Amherst, as well as elsewhere, varies considerably in character and solidity within limited distances, and the ledges in which the quarries are situated apparently represent the more massive portions of the stratum, which have resisted erosion and have hence been left in relief.

An idea of the arrangement of the strata in quarries can be obtained from the following section, which is exhibited in the quarry of L. Halderman & Sons, at Amherst:

	Feet.
Drift material	1 to 3
Worthless shell-rock	6 to 10
Soft rock, for grindstones only	12
Building stone	3
Bridge stone	2
Grindstone	2
Building stone or grindstone	10
Building stone	4 to 7
Building stone or grindstone	12

The floor of the quarry, moreover, consists of good stone, which has been drilled for 12 feet, indicating a still greater thickness of stone which could be extracted.

The other quarries of the region exhibit a similar diversity of material, although the arrangement is not often the same. As regards colors, the stones may be divided into two classes, called buff and blue. The buff stone (Plate E E) is above the line of perfect drainage, and, in the section above given, this extends as far down as the 2 feet of bridge stone, forming a total depth of 23 to 27 feet. In most of the Amherst quarries the relative amount of buff stone is greater.

As will be noted from this section, the different strata are not applicable alike to the same purposes, and the uses for which the different grades of material can be employed depend principally upon the texture and the

hardness of the stone. The softest and most uniform in texture is especially applicable for certain kinds of grinding, and is used for grindstones only, and the production of these forms an important part of the quarry industry. In its different varieties the material is applicable to all kinds of grinding, and stones made from it are not only sold throughout this country, but are exported to nearly all parts of the civilized world. Some of the finest-grained material is also used in the manufacture of whetstones. There are various points in the system of the Berea grit where the stone is adapted to this use, but such a manufacture is best carried on when joined with a large interest in quarrying, so that the small amount of suitable material can be selected; and thus it happens that only at Amherst and at Berea are whetstones manufactured in large quantities.

The stone which is especially applicable for purposes of construction is also variable. That which is of medium hardness and of uniform texture is used for building purposes or for grindstones; some is too hard or not sufficiently uniform in texture for grindstones, and is used for building purposes only; and the material sometimes found which is difficult to quarry and to dress is used for bridge-building purposes only.

As regards appearances there is much diversity in the material produced in this region. There are differences due to diversity of textures, of colors, and of methods of stratification, yet these are seldom recognized by the casual observer. Differences in color give rise to the terms "blue" and "buff" previously referred to, and differences in methods of stratification give rise to the terms "split-rock", "spider-web", and "liver-rock". The regularly and evenly stratified stone is classified as split-rock; that in which the stratification is irregular and marked by fine, transverse, and wavy lines is classified as spider-web; the homogeneous stone which exhibits little or no stratification is classified as liver-rock. These lines of stratification are frequently marked by the presence of black ingredients which are composed of mica and carbonaceous matter. As regards composition, these stones are mainly a siliceous sand; and analyses show that the dry material contains usually as much as 95 per cent. of silica, with a small amount of lime, magnesia, iron oxides, alumina, and alkalies. When first taken from the quarry it contains several per cent. of water, and as long as this is retained the stones cut easily; upon its loss they harden. Analyses made for the Clough and Columbia Stone Companies show that their stones contained respectively 5.83 per cent. and 7.75 per cent. of water when wet, and 3.39 and 4.28 per cent. of water when dry. The stone is extracted during only eight months of the year, since it is injured by being quarried in the winter and subjected to hard freezing while still containing this quarry water. The winter months are, therefore, occupied in stripping and channeling. The average thickness of this sandstone formation is more than 60 feet in these counties, and in many places, as, for instance, at the Brownhelm quarry, it is over 80 feet in thickness. An acre covered by stone only 50 feet in thickness would furnish over 2,000,000 cubic feet. Many very fine buildings, both in the United States and Canada, have been built of the so-called Amherst stone, among which may be mentioned the Canadian Parliament buildings, and most of the public buildings in Toronto; and there is no city in the Union in which stone is extensively used where examples cannot be found in which this stone is used for trimmings and ornamental work.

Near Peninsula, in the northern part of Summit county, on the west bank of the Cuyahoga river, is a valuable outcrop of the Berea grit which has been very extensively quarried in the past, and shipped by canal to Cleveland and thence by lake to various lake ports, principally to Buffalo, New York. The base of the Berea grit is here several feet above the canal. The stone is still shipped quite extensively by canal, and also by the Valley railroad. The principal market at present is Akron. About 16 feet of the upper portion of the stratum are used for general building purposes; below this is a 7-foot course, used principally for the manufacture of mill-stones, for hulling barley and other grains; below this, the bottom course, about 5 feet in thickness, is a rather hard material, used quite extensively for paving purposes. The cap-rock is here about 20 feet in thickness; below this the first 6-foot course of building stone contains more protoxide of iron than the Amherst buff, and has a darker color. The remaining portion of the stratum contains less iron, and much of it is almost white.

The Peninsula stone has the reputation of being exceedingly strong, but it is harder and less homogeneous than that from the Amherst quarries.

The Berea grit has two lines of outcrop in Summit county, one on each side of the Cuyahoga river. The one on the east side passes down to Northampton township, where the stratum lies below the drainage level and contains a considerable amount of soluble compounds of iron, and has a very perceptible odor of petroleum, so that the material is not suitable for building purposes. The stratum has not been quarried to the bottom in this locality, but only about 18 feet in depth. The sheets or layers, so far as quarried, vary in thickness from 6 inches to 6 feet. The blocks of stone are mostly sawed into slabs for sidewalk paving. Still farther south, on the west line of outcrop in the northern part of Portage township, a quarry has recently been opened for the purpose of supplying material for sidewalk paving, and some for steps, caps, sills, etc. This material is similar to that in the above quarry, except that so far as quarried it contains no perceptible traces of petroleum.

The exposed strata of rock in Huron county show evidence of great disturbances and displacement. Sharp synclinal and anticlinal axes are visible in the majority of these exposures, and are most conspicuous in the Berea grit.

In Mr. Perrin's quarry the stratum dips at an angle of nearly 45°. The sheets vary in thickness from 8 inches to 10 feet. This stone is used principally for bridges and foundations. The rock is quarried by first blasting out with powder large masses, which are afterward cut by means of wedges into the sizes required.

In Mr. Grannell's quarry the rock has been less disturbed and lies in nearly a horizontal position. The sheets here are not so heavy as in the above quarry, but the quality of the material is about the same. The layers vary from 1 inch to 5 feet in thickness, and those 6 inches and less in thickness are used principally for paving purposes. The thinner sheets are raised from their bed by means of wedges and bars.

Still farther south in this county, in Fairfield and Greenfield townships, the stratum of the Berea grit is made up almost entirely of thin sheets.

In a quarry in the latter township the sheets vary in thickness from 1 inch to 2 feet, the prevailing thickness being from 1 inch to 6 inches. The material is used almost exclusively for paving purposes, for which it is well adapted, being strong and durable, though much of it is deeply ripple-marked and does not make a smooth pavement.

The line of outcrop of the Berea grit formation is marked by a series of quarries which cross the eastern tier of townships in Crawford county. (*a*) The quarries in Polk township are at present of much less importance than those in Jackson township in the vicinity of Leesville. Quarries have been worked in this vicinity for thirty or forty years. The quarry of the Leesville Stone Company is located about one mile north of the railroad station, but a spur-track is now nearly completed from the main line of the railroad to the quarry. The material from this quarry has earned a good reputation, and the stone has been quite extensively extracted during the last few years. The rock lies below the level of perfect drainage, and in both color and texture it is similar in appearance to that quarried at Berea, but on exposure to the weather its color changes to light gray. Blocks of any desired dimensions may be obtained in this quarry, and the method of quarrying is the same as that employed in the Berea and Amherst quarries. The material is employed for all general building purposes, most extensively, however, for the construction of bridge abutments and piers. It finds its principal markets along the line of the Pittsburgh, Fort Wayne, and Chicago railroad, from Crestline westward into northern Indiana. This quarry is locally more important from the lack of building stone suitable for heavy masonry along this portion of the railroad. Other quarries less favorably located are worked, some with considerable variation in quality, but furnishing material for local use.

In Plymouth township, in the northwestern corner of Richland county, the Berea grit is quarried for the construction of foundations and bridge work in the vicinity of the quarries. Some flagging material is also obtained from the quarry of Mr. Bevier. The material developed in this locality is inferior in quality to the Leesville stone, and on exposure to the atmosphere it is more liable to suffer detrimental discolorations.

The Waverly conglomerate furnishes nearly all the stone for ordinary purposes of construction in the town of Mansfield. In one quarry about 60 feet of rock is exposed. It is considerably broken up; the upper 30 feet being in thin layers, and the lower 30 feet in layers from 1 foot to 6 feet in thickness. Much of this material is beautifully colored in wavy bands of black, yellow, red, and gray, and would make a very ornamental stone if it were not so soft and easily worn by abrasion. It has been used to some extent for purposes of ornamentation in the town of Mansfield. In some of the colored material the red predominates, and the stone is harder but less beautiful in appearance, but it does not exist in large quantities. In another quarry the material is less broken up, and is more uniform in quality, texture, and color.

The Waverly conglomerate in this locality is a coarse-grained sandstone, but rather finer than in most other localities where it is quarried. The light-red and gray-colored samples forwarded to the National Museum were found to be very good and safe stones to work. The dark-red colored specimen is rather coarse and loose in structure.

A section of the quarry of Mr. D. W. Zent, at Belleview, exhibits the following arrangement of strata: (*a*)

	Feet.
1. Earth	2 to 4
2. Coarse pebbles of drift	8 to 10
3. Sandstone in thin layers	15
4. Sandstone in massive layers	8
5. Sandstone in layers of 1 foot to 4 feet	15

There is but little variation in the character of the material except in color. The material has been used principally in the construction of railroad bridges on the Chicago branch of the Baltimore and Ohio railroad. Considerable of the material is used at Lexington, Ohio, and in the neighborhood of the quarry. Only a small amount of powder is used in the extraction of the stone, and the amount of production is controlled by the demand for stone by the Baltimore and Ohio Railroad Company. The layers of stone are from 6 inches to 6 feet in thickness, and open joints occur from 4 to 5 inches in width. About 60 feet of rock are exposed in the quarry at the present time, and the formation has not yet been quarried out to the bottom. The color of the layers near the top of the quarry is brownish; farther down some of the stone has a yellowish appearance, and at the bottom of the quarry is a layer of mottled or clouded stone, a blending of red and brown.

a Geological Survey of Ohio, Vol. III, p. 321: "Geology of Richland County," by M. C. Read.

An abundance of stone of indifferent quality may be obtained in the vicinity of Wooster from the Waverly formation. A little north of the town a much broken sandstone is quarried to some extent for the production of material for building foundations and cellar walls.

The most important quarry in this locality is in the Waverly conglomerate. In this quarry blocks of any desired dimensions may be obtained, and the stone is used principally for the construction of foundations and bridge work. At the joints the material shows a discoloration to a depth of about 1 inch due to weathering. A quality of material rather superior to the above is obtained from the Carboniferous or Sharon conglomerate in Chippewa township, in the northeastern part of the county.

In the quarry of the Walnut Grove Stone Company, operated here, large blocks are obtained for bridge-building purposes, and some of the material quarried is used for the construction of foundations. The principal markets for the material are at Orrville and Wooster, and some is transported to Akron, in Summit county. The material is a coarse-grained though quite firm and durable sand rock, very suitable for heavy masonry. At the natural joints in the quarry the material shows but little discoloration from the effects of weathering. The marketable material here comes almost to the surface; it is necessary to remove only about 3 feet of drift material before the marketable product is reached. The material is quite soft when first quarried but hardens upon losing the quarry water.

The stratum in which the quarries near Massillon, Stark county, are located, according to the concurrent testimony of all the geologists of the Second Pennsylvania geological survey, is the second or middle sandstone of the great Carboniferous conglomerate; it immediately overlies and often cuts out the lowest coal, known as the Sharon seam. Dr. J. S. Newberry, in the *Report on the Geological Survey of Ohio*, confirms the designation of Carboniferous conglomerate for the Sharon conglomerate which lies below the Sharon coal. The Massillon sandstone, in the quarries near the town of Massillon, is quarried by means of channeling and wedging. The courses vary in thickness from 2 to 8 feet, the lower courses being the thickest. The stratification is somewhat undulating, and the courses are not uniform in thickness. Blocks of stone of any desired dimensions may be obtained from any of the quarries devoted to the production of building stone. The entire thickness of the stratum is about 60 feet. This material is employed principally for general building purposes, but it is also manufactured into grindstones, chiefly for dry grinding. According to the testimony of Mr. J. P. Burton, of Massillon, the Massillon sandstone, when subjected to a temperature of 900° F., yet remains in perfect condition. He has used the material for many years in his furnace-stack at the Massillon blast-furnace; and the stone which stood the above test was taken from the quarries of Messrs. Warthorst & Co. and used for a hearth. The texture of the stone is not the same in all the quarries about Massillon, and the finest-grained material is obtained from Mr. John Paul's quarry, about 5 miles north of the town. The upper layers in this quarry are crushed for glass-sand and the lower layers for steel-sand, and but little of the material is used for purposes of construction. Powder is used for removing the cap-rock, which varies in the different quarries from 2 to 10 feet in depth, and for extracting the material for glass- and steel-sand.

All three horizons are worked for the Youngstown market. The Briar Hill and Bear Den quarries belong to the middle horizon, and those of Austintown to the highest. The ledges in this locality, as a rule, grade upward in fineness, and the upper stones give the best results when dressed. All of them are nearly pure silex, and the waste material of the Briar Hill quarry is all ground or crushed and sold to the steel works; much of it is adapted also to coarse-glass manufacture. The rock of the middle ledge is colored in bands and lines with iron peroxide, which robs it of beauty, but interferes in no way with its durability. In all northeastern Ohio there is no limit to the amount of strong, massive, and durable building stone to be obtained. The quarries in the middle division of the conglomerate series, on account of the more favorable situation of the outcrops, are more largely worked than the quarries in the upper and lower divisions.

The Austintown quarries have been worked at intervals since the country was settled. The stone is light-brown in color, rather coarse, but uniform in texture. It is used to some extent for purposes of ornamentation in Youngstown, but its principal uses are for general building purposes and bridge work. Flag-stones of fair quality are also quarried here for the local demand, from a horizon just below the sandstone ledge. Blocks of any desired dimensions may be obtained from the middle division of this series, and the material is used principally for general building purposes, bridge work, and to a small extent for ornamental fronts. The principal market for all these quarries is Youngstown. Some material is shipped from the Briar Hill quarry to Pittsburgh and some is used for purposes of construction by the New York, Pennsylvania, and Ohio railroad.

Stone for local uses may be obtained almost everywhere in Tuscarawas, Holmes, and Knox counties, and for this reason no extensive quarry is worked. A quarry was opened and developed for the purpose of extracting material for bridge construction on the line of railroad running near the quarry, but is now nearly abandoned, because this railroad obtains building stone in cuts through the same stratum. This stone lacks the uniformity of texture and color demanded for the better class of work.

There are a number of ledges of sandstone, about 20 feet in thickness, found at different horizons in the Lower Coal Measures in Tuscarawas county, and they all furnish some building stone. A considerable portion of the building stone used in the county is obtained from masses of rock which have been detached from the solid ledges.

The stone from the quarry of the Tuscarawas Valley Coal and Iron Company is finer in texture and of a more uniform color than any other stone obtained in the county. It is used for "bottom" in the blast-furnace belonging to this company, and resists the action of heat uncommonly well. The principal uses of the material from these quarries are for constructions of foundations, underpinnings, and bridges in the vicinity in which the quarries are located.

Almost everywhere in Holmes county there are lying on the surface large masses of rock which have been detached from the strata of the Coal-Measure sandstones. These detached masses supply the local demands for building stone, and no quarries are developed in the ledges.

Near the central part of Knox county, from 3 to 7 miles northeast of Mount Vernon, large masses of rock lie loose upon the surface. These have not been transported to their present station, but have been left in loose blocks on the surface by the undermining and removal of a portion of the soft shales that immediately underlie the stratum of sandstone. The quarry operations represented by Messrs. Bartlett Brothers are worked in these masses of sand-rock. This stone is considered the best material for building purposes to be found in the vicinity of Mount Vernon. It is used for all general building purposes, including caps, sills, columns, etc., in the town and through the neighboring country. It is estimated that about 250,000 cubic feet may be obtained in some places from the surface of half an acre in area. This material has been a source of local supply for about seventy years.

The Waverly conglomerate, which is quarried near Howard station, is not so highly esteemed as is the stone of the Carboniferous conglomerate, described above. The demand for it is principally for use in the construction of railroad bridges, arches, culverts, and to some extent for foundations and underpinnings. Some is shipped to Columbus, Ohio. The layers of stone in this quarry vary in thickness from 6 inches to 6 feet, and blocks of any required dimensions may be obtained. It is rather soft when first extracted, but hardens on exposure to the weather.

In Morrow county the Berea grit crops out, and is quarried in North Bloomfield, Washington, Gilead, and Lincoln townships. Its total thickness varies from 15 to 40 feet in different localities. The thin layers of its upper portion are very even and compact, and make an excellent flagging material. The most favorable development of the flag-stone occurs near Iberia. At this place the layers vary in thickness from 1 inch to 6 inches, but $2\frac{1}{2}$ inches is the most common thickness; the total depth of flag stone is about 20 feet, below which from 18 to 22 feet of heavier layers occur. The quarries are located in the bed of a stream, and only the thin layers are extracted. The amount of flag-stone that may be quarried in this vicinity is practically inexhaustible. At present the material is carried on wagons 2 miles to the nearest railway shipping-point, and a considerable portion of the product of the quarries is carried on wagons to the town of Galion, in Crawford county, which is the principal market for the stone quarried in the northern part of Morrow county.

The thickness of the heaviest layers in the county is only about $2\frac{1}{2}$ feet.

The Berea grit crosses the eastern part of Delaware county, and at Sunbury quite important quarries have been developed. It has here been worked to the depth of about 20 feet, as deep as natural drainage is available. Good building stone might be obtained below this depth, but artificial drainage would be required. Plate F F represents a surface of the Sunbury freestone. This material bears a close resemblance to the Euclid "blue-stone" of northern Ohio. The layers vary in thickness from 3 inches to 3 feet. The thin layers are quarried for flagging stones, and the heavy ones for general building purposes and to some extent for ornamental work. The material finds its principal markets at Delaware, Mount Vernon, Columbus, and Orrville, Ohio. Examples of it may be seen in the building of the Ohio Industrial Home for Girls in Delaware county, and in the National Bank building at Delaware.

The sandstone of the Berea grit in the eastern part of Franklin county has considerable local value, because on each side of its outcrop the surface of the country is occupied by a belt of shale from 8 to 10 miles in width, the belt on the west being entirely destitute of building stone and the one on the east is nearly so. The formation has, however, in this part of the state lost many of the valuable qualities which characterize it in Erie, Lorain, and Cuyahoga counties. On account of its accessibility, however, it has been used quite extensively in Columbus, the Ohio Institution for the Blind being constructed of it as well as several stone fronts.

The entire product of a quarry 10 miles east of Columbus is sawed at the quarry for caps, sills, ashlar, etc., and shipped to various points along the lines of the Baltimore and Ohio and Pan-Handle railroads, but principally to Columbus.

The greater portion of the surface of Licking county is occupied by the rocks of the Waverly formation, but a portion of the eastern part of the county is occupied by the conglomerate and Coal-Measure rocks. The Waverly conglomerate crops out in bold cliffs over quite an extensive area in Madison and Hanover townships. It has been quite extensively quarried in this vicinity for use as material for construction on the lines of railroad running through this section of the county. It is a rather coarse-grained sandstone, in some localities quite uniform in texture, and in others containing pebbles sometimes an inch in diameter. It is rather soft when first quarried, and works rather easily, but hardens on exposure. In some places sections of this conglomerate 100 feet in thickness are exposed in ravines. The quarries now operated are located in the banks on each side of the Licking river. One quarry is located in the north bank, at the foot of which runs the Ohio canal, which furnishes the means for transporting the material to Newark and Columbus, where it finds its principal markets. Another quarry is located in the south

bank, at the foot of which passes the Baltimore and Ohio railroad. The material is used quite largely for heavy masonry along the lines of railroad, and for general building purposes at Newark and Columbus. It varies in color from gray to light brown. The cap-rock necessary to be removed seldom exceeds 4 feet in depth, and consists principally of soil, loose sand, and gravel.

This material may be obtained with equal advantage on the line of the Pan-Handle railroad, and there is no limit to the amount of strong and durable sandstone which may be extracted in this vicinity. A quarry 1½ miles south of Newark, in the Cuyahoga shale, furnishes a fine-grained and homogeneous material, at present used principally for foundations at Newark and Columbus, Ohio. Trinity church, at the latter place, was constructed of this material, and the only defect noticed in the stone is the discoloration. It gives evidence of both strength and durability when laid on its natural bed, and when it is quarried sufficiently early in the season to allow it to become thoroughly dry before being subjected to the action of frost.

The Waverly sandstone seen in Fairfield county in the cliffs along the Hocking river is generally coarse-grained, often passing into a true conglomerate; and it shows the same character in the hills and highlands west of the river. It is more commonly of a rich yellow color, but sometimes of a darkish brown. In many places the stone is firm in texture and capable of resisting great pressure without crushing. (*a*) The stratum in which the quarries near Lancaster are worked is solid, and about 30 feet in thickness. There are but few joints, and the largest sized blocks may be obtained. The material is used principally for bridge construction, canal locks, and general building purposes. The principal markets for this material are Columbus, Centerville, and Lancaster, Ohio. The material for the superstructure of the Saint Joseph's cathedral at Columbus was obtained from the quarry of Messrs. Sharp & Crook, and that for the foundation of the same structure from quarries in the Waverly conglomerate near Hanover, Licking county. The amount of cap-rock to be removed is from 3 to 4 feet in some localities, and as much as 25 feet in depth in other places. Powder is employed in quarrying.

The Lithopolis quarries are located in the lower portion of the Cuyahoga shale of the Waverly group. There are several horizons of building stone in the Waverly group, but this particular portion of the Cuyahoga shale is quite rich in quarries, especially in southern Ohio. There is a number of important quarries in the upper member in different parts of the state, as indicated in the tables. The lower portion of the Cuyahoga shale has no economic importance in the northern part of the state. The only important quarry in the whole formation in northern Ohio is that of the Austin Flag-stone Company, in the upper portion of the shale. In southern Ohio the most important building-stone quarries are in the lower portion of this shale.

The stone quarried at Lithopolis and at other localities at or near the same horizon is commonly denominated freestone. It is a fine-grained sandstone, usually in quite thin courses; is sawed easily, and answers a very convenient purpose for caps, sills, and stone fronts. Columbus, Ohio, is the principal market for the product of the quarries.

Stone for the ordinary purposes of construction may be obtained in various localities in Hocking county, but only one quarry is developed in the Waverly conglomerate near Logan, and the material from this has but recently come into the market through the facilities for transportation afforded by the construction of the Hocking Valley railroad. There are no important quarries below this point in the Hocking valley. The stratum of the Waverly conglomerate in this locality consists of three layers, each about 10 feet in thickness. The rock underlies an area of four or five acres with a cap-rock but a few feet in depth, consisting of clay and gravel, which is easily removed. The quarry is located close to the railroad and is capable of supplying any demand for material likely to be made upon it. It finds its principal markets at Columbus, Lancaster, and London, Ohio, and has been shipped to some extent to Marion and Winnemac, Indiana.

When a canal was constructed through the valley fifty years ago, it furnished easy transporation for the great ledges of sandstone that bound the valley for a dozen or more miles, and the stone from Waverly, Pike county, soon became famous in Columbus and central Ohio generally as Waverly stone. The name was early extended to a great group of associated sandstone and shales of sub-Carboniferous age, as has recently been proved, but the real age was long an unsettled question; hence comes the Waverly group of Ohio geology. It is the first sandstone, except the local Euclid blue-stone, reached in ascending the geological scale of Ohio that can be quarried. The stratum is best shown from Waverly south for 10 or 12 miles. It dips below drainage just south of the county line on the river's bed. For these 10 or 12 miles it is reached on all the ravines on each side of the river. The stone about Waverly has been followed back under such heavy cover that the increased expense of quarrying has ruled the material out of the market. A quarry at Piketon has just been made possible by the Scioto Valley railroad, constructed four years ago. There is, however, no first-class stone now available in this quarry. There are 26 feet exposed in it in courses varying from 1½ to 24 inches in thickness. There is a great amount of reliable stone in the stratum and a great amount that is treacherous. It is by no means equal in uniformity of quality to the Berea stone of northern Ohio. It formerly furnished a grindstone grit of great local value. The stone is always ripple-marked and bears other evidences of having been formed on a shore-line. It is usually of a uniform gray color, but there is also a variegated variety clouded with red which is one of the most striking stones of the state.

a Geological Survey of Ohio, Vol. III, p. 594.

The above, however, is but an inadequate statement in regard to the range of quarries that for many years held the first place in southern Ohio. Many other ledges of at least equal value have now been rendered available by the new lines of railroad communication.

The Waverly stone, where it has not been subjected to atmospheric influences, has the characteristic bluish-gray color of the Berea grit formation in other parts of the state. The difference in composition between the weathered portion and the blue-stone is shown in the following analysis made by Professor Wormley for the *Report on the Geological Survey of Ohio:*

	No. 1 (white-stone).	No. 2 (blue-stone).
	Per cent.	*Per cent.*
Silicic acid	91.30	91.00
Protoxide of iron	0.86	1.17
Sesquioxide of iron	0.06	0.30
Alumina	5.79	5.20
Lime	Trace.	Trace.
Magnesia	0.32	0.28
Water, combined	1.30	1.80
Total	99.63	99.75

Near Cynthiana, where the variegated variety above referred to occurs, there is also found a very white, fine-grained variety, and the following analysis shows this to be very nearly of the same composition as that above, without the oxides of iron:

	Per cent.
Silicic acid	91.35
Iron, sesquioxide	Trace.
Alumina	6.00
Lime, carbonate	0.75
Magnesia, carbonate	0.34
Water, combined	1.00
Total	*a* 99.44

The Waverly brownstone quarries lie at a horizon about 40 or 50 feet above the Waverly stone, or Berea grit, in its southward extension. They lie very near the horizon of the famous Buena Vista stone of Scioto county. A number of the best stone fronts at Columbus, Ohio, have been constructed from the product of these quarries. The stone is brown only on the outcrop; when found a few feet under cover it assumes a dark blue color and loses its value as an ornamental stone. The blue variety contains a large amount of soluble iron protoxide which produces a bad discoloration on exposure to the atmosphere. The following analysis made by Professor Wormley for the *Report on the Geological Survey of Ohio* shows the composition of the Waverly brownstone:

	Per cent.
Silicic acid	73.90
Protoxide of iron	.....
Sesquioxide of iron	13.44
Alumina	8.56
Lime	Trace.
Magnesia	0.46
Water, combined	3.30
Total	99.66

The quarry which has been the most important is located about half way between Waverly and Piketon. Here the stone forms a massive bed 8 feet in thickness. The same ledge has been worked along the valley on both sides of the Scioto river for 10 or 12 miles. That quality of stone still remains in easy reach, though some of the quarries have already yielded all their brownstone to the market. The depth of cap-rock to be removed in these quarries nowhere exceeds 15 feet.

All the ravines that reach the Ohio valley below Portsmouth for 20 miles disclose a large amount of excellent building stone, but in the ravines that are found from 2 to 4 miles below there is a horizon disclosed that lies low enough to be easily reached, and that is naturally covered by an easily-eroded cap, so that a very considerable amount of building stone has been found readily accessible. This horizon is at about the middle of the sub-Carboniferous system in Ohio.

The Portsmouth quarries have been worked since the first settlement of the Ohio valley. During the last fifty or sixty years a great number of separate quarries have been opened, but all on the same horizon. When the stripping becomes heavy a slight change in location is made. The land is considered of no great value for any other than quarrying purposes. Some locations prove better than others, and these are being worked more systematically of late years.

a Geological Survey of Ohio, Vol. II, p. 623.

At the quarry of Messrs. Reitz & Co. the stone occurs in layers from 6 to 24 inches in thickness. These courses are frequently separated by an inch or two of shale. Joints do not occur frequently to interfere with the systematic working of the quarries. For flagging the stone is unequaled in the Ohio valley, as it wears evenly, always gives foothold, and is in every way satisfactory. It is well adapted to sawing, and is used quite extensively for general building purposes. The material finds its principal markets along the Ohio valley, through Ohio, West Virginia, Kentucky, and Pennsylvania. It has been used in the construction of the court-house at Athens and the Children's Home building at Gallipolis, Ohio, and the Western penitentiary of Pennsylvania, at Allegheny.

The quarry of Mr. J. M. Inskeep is located about 12 miles below Portsmouth, on the Ohio river, at a horizon about 60 feet above the Buena Vista stone proper. There are 30 feet of rock in about 20 different layers. The lowest course, about 32 inches in thickness, is the most valuable stone. This course is covered by 4 feet of blue shale, which is the largest mass of shale in this section. The other shale deposits are but little more than partings between layers of sandstone. The courses are remarkably even in thickness, but those above the lowest do not yield a strictly first-class material. For the last three or four years this quarry has supplied material quite extensively for the Columbus market, and a number of fine stone fronts have been constructed from it. The stone varies considerably in quality, and needs to be carefully inspected.

The southwestern portion of Scioto county and the southeastern corner of Adams county, two adjoining districts, were once the most important localities in Ohio for the production of building stone. In the earlier days of the state an engineer of reputation, employed upon the construction of canals, became conversant with the then known building stones of the state, and recognizing the great value and accessibility of the ledge, commonly known as the Buena Vista Freestone ledge, bought a large territory here, and began the development of the quarries in a large way. Other horizons of good rock were found at various levels, but this one bed, by its color and quality, supplied the Cincinnati market almost exclusively. Its reputation spread throughout the whole Ohio valley and beyond. Large quarries were opened on both sides of the river, government patronage was secured, and material for the construction of custom-houses and other public buildings was ordered from the Buena Vista quarries. So great was the demand for this stone that material of poor quality as well as of good was hurried into the market. The greenstone while full of quarry water was laid in massive walls, and the bad behavior of this material soon excluded the stone almost entirely from the market. It is, however, as good now as when it earned its high reputation, but needs careful and conscientious selection and suitable seasoning.

Just below the horizon of the Buena Vista stone lies the Berea shale, a bed of highly bituminous and very fossiliferous black shale, ranging from 15 to 30 feet in thickness. Its bituminous composition makes it a source of petroleum, which rises into the sandstone courses that lie above it. This is the source of one of the worst impurities of the Buena Vista stone. When followed under cover it is found loaded with petroleum or with tar, which seems not only to disfigure the stone but to weaken it to some extent; and other impurities in the stone are masked for the time by this bituminous matter. The oil-bearing stone is tolerated only in rough, heavy work. Some of the stone contains sulphide of iron, which, on exposure to the weather, becomes oxidized to the sulphate and goes into combination with compounds of aluminium, and appears on the surface of the stone as a white efflorescence which has the characteristic taste of alum. Grains and nuggets of pyrites appear in the shales associated with this sandstone, but are not very perfectly visible to the naked eye in the city ledge (the name now applied to the stratum proper of Buena Vista stone). The rock is quarried by channeling and wedging in the same manner as in the quarries of the Berea grit in northern Ohio. No stone is extracted for the market during the winter months, but this time is occupied in removing the cap-rock and in channeling. The behavior of the material when properly selected is apparent in a number of important structures in Cincinnati, and that of the unselected material may be seen in the custom-house and other buildings in Chicago. The material has also been used with good and bad results in a number of other cities and towns, including Louisville, Kentucky, Pittsburgh, Pennsylvania, and Detroit, Michigan.

Carboniferous.—The Carboniferous conglomerate (Sharon conglomerate of the *Second Geological Survey of Pennsylvania*) furnishes the only important building stone in Portage county. This formation in Ohio geology is commonly called "the Conglomerate".

In Franklin, Mantua, and Nelson townships, where it is well seen, it is a coarse, drab-colored sandstone, in places thick set with quartz pebbles from the size of a pea to that of an egg. It is quarried in these localities to a small extent for local purposes.

At the quarry of Messrs. Case & King, in Windham township, it is finer, whiter, and more homogeneous, and answers quite well for architectural purposes. It is rather too coarse for fine work, but it is strong and durable and well adapted to bridge building and all other plain and massive masonry.

In Summit county the Carboniferous conglomerate underlies all the higher portions of the county and forms the surface rock over all the middle portion, except where cut through by the Cuyahoga and its tributaries; though generally covered and concealed by beds of drift, it is exposed and quarried in all the towns north of Akron. In the valley of the Cuyahoga it forms cliffs sometimes 100 feet in perpendicular height. The rock is about 100 feet

in thickness, generally a coarse-grained, light drab sandstone, but in some localities, and especially near the base of the formation, becoming a mass of quartz pebbles, with just enough cement to hold them together. (a)

All the accessible material that is now known in this formation is applicable to ordinary purposes of building. Although it is quarried in many different localities for local supply, it is worked extensively in but two localities—at Akron and in Twinsburg township. The quarries at Akron are worked principally to supply the town with foundation stone and the immediate vicinity with bridge stone. The quarries in Twinsburg township are at present worked quite extensively to supply material for the construction of bridges on the Cleveland and Pittsburgh and the Connotton Valley railroads.

A section in Mr. Parmelee's quarry exhibits 18 inches of soil and gravel, 15 feet of coarse sandstone in which thin strata of pebbles occur from 1½ to 4 feet apart, and 6 feet of very coarse conglomerate underlaid by shale. The 15 foot course of sandstone occurs in a solid mass, which separates easily where strata or sheets of pebbles called "bed-seams" occur. In the Akron quarries the stone is fine-grained and more homogeneous than in the Twinsburg quarries. In Mr. Hugill's quarry the rock has been quarried to a depth of 40 feet, and the material obtained is a coarse-grained sandstone free from pebbles. Formerly, in a quarry known as Wolf's quarry, near Akron, a local stratum produced a deep reddish purple sandstone, perhaps the most beautiful building stone ever produced in the state, which was used quite extensively in Cleveland, and two residences on Euclid avenue are constructed of this material. At Cuyahoga Falls a similar material has been quarried to some extent for the construction of buildings in the town. The quantity of this variety of building stone is apparently not large, and it seems that it is nowhere known at present where it can be profitably quarried in a large way. The Wolf quarry has not been worked for a number of years.

The stone quarried for building purposes in Coshocton county is obtained from blocks detached from strata of sandstones of the Lower Coal Measures. The stratum from which the blocks quarried by the parties represented in the tables have been detached is a solid ledge 30 feet in thickness, and lies a few feet above the horizon of the Zoar limestone. The material is usually a light-colored sandstone, though some of it has a reddish color, and some is a finer-grained white sandstone. The stone used for the construction of locks on the Ohio canal, through Coshocton county, was obtained from these quarries. The stone has the reputation of enduring well ordinary atmospheric influences, but not of withstanding a high degree of heat. It is principally used for bridge building and foundations in the vicinity of the quarries.

Material for ordinary purposes of construction is obtained in various localities in Muskingum county from the Coal-Measure sandstones, but there is no extensive quarry at any place except about half a mile east of Zanesville. This quarry furnishes by far the largest part of the stone used for construction in and about Zanesville. It has been used quite extensively for building canal locks, foundations, and for sidewalk pavements. Some of the oldest buildings in Zanesville are constructed entirely of this material, and it is found that the stone is more capable of resisting atmospheric agencies than of resisting the abrasive action to which it is subjected in sidewalks. This material is easily obtained in great abundance and of fair quality, and is the most important among the building stones found in the neighborhood of Zanesville, except perhaps the sub-Carboniferous limestone with which it has been recently brought into competition.

The most important building-stone quarry in Noble and Guernsey counties is near Cumberland, on the line between the two counties. The stratum quarried is solid and about 10 feet in thickness. The material is a dense fine-grained sandstone, rather hard, but susceptible of being finely carved. It is of a gray or light-brown color where it has been subjected to atmospheric influences, but as the excavation progresses into the hill a material of a bluish-gray color is obtained. Joints in this stratum are filled up with a hard calcareous matter deposited from solutions of the material from a limestone ledge a short distance above the sandstone. The size of blocks determined by these joints is about 30 by 15 by 10 feet. The material is employed for all general building purposes, principally at Cambridge. It is used in the superstructure of the court-house in process of construction at this place. The foundation stone for this building was obtained near Cambridge, from a quarry worked only to supply temporary demands.

Stone for the ordinary purposes of construction may be obtained in various localities in Jefferson county from the different sandstone strata of the Coal Measures, which occupy the whole area of the county; but the only quarries that have been developed are those near Steubenville, in the Upper Coal Measures.

One quarry furnishes stone for general building and paving purposes, used principally in the town of Steubenville. The material has a bluish color where it has not been exposed to atmospheric action, and at the natural joints discoloration has penetrated into the rock from 10 to 18 inches. This liability to discoloration makes this stone unfit for the finer purposes of construction.

A better material for purposes of ornamentation is obtained from the quarry where two separate and distinct strata of sandstone in the Upper Coal Measures occur. There are, in reality, two separate quarries, located at different heights, at the side of a hill west of Steubenville, near the Ohio river. The material from these quarries is used largely for cemetery work, bases of monuments and tombstones, vaults, etc. That from the upper quarry

a *Geological Survey of Ohio*, Vol. I, p. 212: "Geology of Summit County," by J. S. Newberry.

is better adapted to fine work, but it is not so extensively used, because the material is not as accessible as that in the lower quarry. The Episcopal church at Steubenville was constructed of stone from these quarries.

Belmont county is well supplied with material for the ordinary purposes of construction from the sandstones of the Upper Coal Measures and the Lower Barren Measures; and some of the quarries furnish material quite well adapted for ornamentatal purposes. The most important quarries are those in the eastern part of the county, near Martin's Ferry and near Bellaire. These quarries are located in the hills several hundred feet above the Ohio river. The quarry of Mr. Charles Siebrecht is located about 100 feet high in one of these hills. The stratum is a solid mass about 30 feet in thickness. The material is used for general building purposes, principally at Martin's Ferry. The stone work of the suspension bridge across the Ohio river at Wheeling, West Virginia, is constructed from this material.

The total thickness of the sandstone ledge quarried by Mr. Robinson, near Bellaire, is about 40 feet. The rock, for a depth of 17 feet from the top, is very uniform in texture and general appearance. The portion of the ledge below this is in irregular masses, unfit for building purposes, and is locally called "nigger-head". The layers of stone in the upper 17 feet are quarried for building purposes, and vary in thickness from 4 to 7 feet. This is esteemed as the best material for building purposes found in Belmont county. The arches and abutments of the Baltimore and Ohio Railroad bridge across the Ohio river at Bellaire, and of a number of other bridges on the same railroad, are constructed of this stone. The material finds its principal markets at Bellaire, Ohio, and at Wheeling and Benwood, West Virginia. Traces of coal vegetation are found occasionally between the layers of stone in this quarry. A short distance above this sandstone a vein of coal occurs, and above this a limestone stratum 20 feet in thickness, quarried for furnace flux.

The ledge of rock in Mr. Hutchinson's quarry is about 30 feet in thickness, and is considerably broken into irregular masses. The stone is fine-grained, rather hard, and difficult to cleave in any direction. Near the middle of the ledge are two layers, each about 20 inches in thickness, which are more regular; the rock, however, is found less broken as the excavation advances into the hill. Since this quarry is constantly worked for ballast, it has the advantage of selecting its best material for purposes of construction. However, stone more regular in structure and better adapted to building purposes is quite abundant in this locality. There is also a good flagging stone found here in a different stratum; but this is quarried only occasionally for temporary demands. The product of the quarry of the Baltimore and Ohio Railroad Company, near Barnesville, is used largely for ballast. It has been used to some extent for purposes of construction on the Baltimore and Ohio railroad. The stratum in which the quarry is located is about 30 feet in thickness, but has only been worked to a depth of 14 feet. The stratum contains few joints and has no divisional planes of stratification. Stone of such fair quality for all ordinary building purposes is so generally distributed throughout this part of the county that it is picked up wherever needed to supply the occasional local demands, and no extensive quarries are developed at any place for the production of building stone.

In Washington county strata of sandstone belonging to the upper series of Coal Measures are quarried for the production of building stone and grindstones in the heavy ledges along the Ohio River hills. The most important quarries are located near Marietta and Constitution. The arrangement of the different sandstone strata, with their alternate shales, coals, and fire-clays, is as follows:

Heavy sand-rock	30 feet.
Blue shale	9 feet.
Heavy sand rock extensively quarried for grindstones	25 feet.
Sandy shale	20 feet.
Heavy sand-rock quarried in places	36 feet.
Shale, somewhat ferruginous	4 feet.
Coal, Hobson's seam	1 foot to 6 inches.
Fire-clay and shale	4 feet.
Interval to Ohio river	a 42 feet.

The quarries near Marietta and Constitution are all, except Mr. T. B. Townsend's, worked in the grindstone stratum, and produce, besides grindstones, material for all general building purposes. The building stone is used principally at Marietta and at various points along the Ohio river. In different portions of the stratum there are sufficient varieties of texture to furnish all kinds of grits used for wet grinding, and the grindstones are shipped to all manufacturing points in the United States. The rock splits readily in the direction of the stratification. The advantages offered for the transportation of the product by the proximity of the quarries to the Ohio river greatly aid their development.

The quarry of Mr. Townsend is located on the Muskingum river, and is devoted to the production of a material mainly for bridge-building purposes, and some for general purposes of construction. The section exposed in this quarry exhibits 65 feet of sand-rock, which becomes still heavier as the quarry progresses into the hill. It consists of layers from 4½ to 18 feet in thickness. In the lower portion of the quarry the material is rather finer in texture and superior in quality to that in the upper portion. The quarry was opened for the special purpose of obtaining stone for the ice harbor, now in process of construction at Marietta; but it also furnishes material for other structures.

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a Geological Survey of Ohio, Vol. II, p. 472: "Report of Second District", by E. B. Andrews.

LIMESTONE.

CINCINNATI GROUP.—The southwestern corner of Ohio is covered by what is called the Cincinnati group of limestones, a geological formation equivalent to the Hudson River beds of New York. These rocks were very early quarried and used for construction purposes, although the special quarries that are at present in operation have been much more recently developed. Quarries once located on the outskirts of Cincinnati have suspended operations on account of the growth of the city. The material is mentioned in the early reports upon the geology of Ohio as having been used in 1838 for building, burning into lime, macadamizing roads, and even for ornamental purposes. (*a*)

Professor Orton gives the following as the order in which the beds which constitute the Cincinnati group in southwestern Ohio are arranged:

The Point Pleasant beds, 50 feet thick, constitute the lowest of the series. The Cincinnati beds proper overlie these, and are 425 feet thick. The Lebanon beds are the highest, and are 300 feet thick. Quarries are developed in each of these horizons. The rocks wherever they are quarried are very much alike, and are called in commerce blue limestones. As a rule they are filled with fossils, and occur in layers that are from half an inch to 12 inches in thickness, which are interstratified with beds of shale or clay. Professor Orton says that while this blue limestone has been used from the first settlement of the country, it has hitherto enjoyed the reputation of being serviceable rather than beautiful; but within the last few years it has been so treated by combination with other building stones as to produce very fine architectural effects, as can be seen in the recent buildings of the city and suburbs of Cincinnati. (*b*)

The quarries in the Cincinnati group of limestones are located near Cincinnati, more on account of the local demand for the most accessible stone than for the superior quality of the material at this point. There are limestones in the river bed which are upon the same level as the quarries which produce excellent stone at Covington, upon the opposite shore. These beds are overlaid by 250 feet of shales, which are called by Professor Orton the "Eden shales"; and these in turn are overlaid by the so-called "Hill Quarry" beds of limestones, from which most of the stone used in the county is derived.

Six quarries of importance are at present in operation at Cincinnati with exposures of from 40 to 75 feet, of which some 10 to 25 feet is distributed throughout the section in layers from 1 inch to 10 inches in thickness. Slabs 6 feet long and 6 feet wide can be extracted.

The lime which is burned from the stones of the Cincinnati group is dark and unfit for plastering, but for foundations, etc., it is of especial value, as it possesses some hydraulic capacity. Specifications for cellar walls, bridge abutments, etc., in this region always call for Cincinnati lime.

It is thus seen that the stone is interstratified with beds of shale, which forms from one-fourth to one-third of the whole section. In other parts of the series the proportion of stone falls to one-tenth of the thickness of the section, the main mass being composed of shale or clay. The stone seldom exists in such condition as to make a building stone that can be used in fronts, and it is mainly employed for rough construction, although some of the churches in Cincinnati have been built from it.

As the dip of the blue-limestone beds is mainly to the north, while the direction of the Ohio valley at Cincinnati is toward the south, by proceeding up the river layers of the formation are brought to the surface that are lower than any occurring in the river quarries of the city. The Point Pleasant quarries, in Clermont county, are consequently situated in a different and lower level, and Professor Orton states that this section furnishes the most desirable building stone of the blue-limestone series. It dresses more easily and possesses a better shade of color, combined with a general exemption from the weathered seams that disfigure the higher beds. The quarries are situated at the water's edge, and river transportation enables the stone to be brought to the city easily. In a church on the corner of Eighth and Elm streets, Cincinnati, the appearance of the stone can be seen to the best advantage. As the demand for the stone is local, the annual production fluctuates between wide limits, and the value of the product has sometimes fallen very low. There is quite a large number of small quarries in the neighborhood, each producing from $200 to $300 worth of stone annually.

The quarries in Butler county, from which are extracted the blue limestones of the Cincinnati group, are situated at and near Hamilton. The character of the stone and the method of its occurrence are the same as those of the other limestone obtained from this group. A quarry at Hamilton exhibits a section 40 feet thick, of which 18 feet are of stone distributed in layers of varying thickness throughout the whole section. The individual layers are from 1 inch to 12 inches in thickness, and the heaviest layers are found at the bottom.

The limestones of the Cincinnati group are all highly fossiliferous, and the number and variety of the forms found in them have given to them a geological celebrity. The quarrying operations are constantly bringing to light rare and interesting species, but the specimens which were collected and sent to the National Museum as typical contain a predominating number of fossils of the species Chaetetes, with the shells of brachiopods cemented together by limestone. When polished the stones appear very beautiful on account of the diversity and delicacy of these fossil forms, but owing to the presence of clay in the cementing material the polish is not uniform

a Professor Locke in *Second Annual Report on Geological Survey of Ohio*, by W. W. Mather, 1838.
b *Report of the Geological Survey of Ohio*, Vol. I, Part i, p. 378.

over the whole surface. This does not detract especially from the value of the stone for ornamental purposes, since the fossil forms which give the stone its beauty by receiving the highest polish are thereby brought into prominence.

The fragments of fossils of which the stone so largely consists were apparently first washed together along with the clayey limestone and mud which forms the cement, and which fills the interiors of the fossil forms. This was apparently solidified into a vesicular rock, and the cavities were subsequently filled with clear crystalline calcite. The process of such formation is frequently seen in the Ohio limestones, some of which are porous, and are filled with cavities which are but partially filled with new crystalline product. Analyses were made of these limestones by Dr. Wormley for the *Report on the Geological Survey of Ohio.* (*a*)

The Point Pleasant rock, which is considered to be the best for building purposes, was by him shown to have the following composition:

	Per cent.
Siliceous matter	12.00
Alumina and iron oxide	7.00
Calcium carbonate	79.30
Magnesium	0.91
Total	99.21

NIAGARA GROUP.—The rocks of the Niagara period occupy that portion of Preble county in which quarries are extensively developed. The Niagara limestones in Ohio are very often called the Cliff limestones, because they stand in bluffs along the river valleys, and they are more esteemed as building stones than the rocks of the underlying Cincinnati group.

The following sketch by Professor Orton shows the arrangement of the rocks in this county: (*b*)

Upper Silurian { Niagara group { Guelph. / Springfield stone. / Clinton limestone { Niagara shales. / Dayton stone.

Lower Silurian, Cincinnati group, Lebanon division.

The approximate thicknesses of the divisions are about as follows:

	Feet.
Niagara group	75
Clinton limestone	15
Cincinnati group	225

Of these stones the blue limestone is quarried in the southern part of the county, and was formerly the main dependence in that region as a source of lime, but the Cliff limestone was brought subsequently into universal use as a substitute.

The Clinton limestone has been largely in demand for chimney-backs, and has been found especially desirable for all those constructions which are exposed to fire or heat. It is an unevenly-bedded stone, often sandy in texture, but no quarries are so extensively developed in it as to merit consideration.

The stone which is quarried near Eaton is the geological equivalent of the building stone of Springfield and Yellow Springs. One of the largest and oldest of the quarries is 3 miles northeast of Eaton; another, 5½ miles northeast of Eaton, is smaller. A section of the first quarry shows 6 feet of so-called cutting stone at the bottom overlaid by 4 feet of a good building stone with 3½ feet of drift material upon the top. A number of grades of material are quarried, and stone suitable for flaggings and copings, as well as for fine and rough constructions, is obtained.

It is stated that a stone 10 by 12 feet in superficial dimensions has been taken out, and that very much larger stones can be obtained. It is principally used for rough building purposes and is sent to Eaton, Ohio, and to Richmond, Indiana, by team and by rail.

These quarries yield an unusually fine quality of flagging stone, the material lying in very even courses of suitable thickness. An analysis of the limestone was made for the Ohio survey by Professor Wormley, (*c*) and the composition of the stone is shown to be as follows:

Calcium carbonate	49.75
Magnesium	35.87
Alumina and iron oxide	4.40
Siliceous matter	9.40
Total	99.42

a Geology of Ohio, Vol. I, Part 1, p. 374.

b Geological Survey of Ohio, Vol. III, Part 1, p. 405.

c Report of the Geological Survey of Ohio, Vol. III, Part 1, p. 409.

The largest quarries in Preble county are located at New Paris. The building-stone courses are here accessible, but the production of burned lime is the chief industry, yielding twelve-nineteenths of the gross earnings; the lime is distributed mainly to the westward by the railroads leading out of Richmond, Indiana. The quarries produce also flaggings, copings, bridge and building stones—in fact, the material for any construction can be here obtained.

Immense blocks are said to have been quarried at this place. The chief market for the stone quarried at New Paris is in eastern Indiana. The specimens sent to the National Museum from Preble county are all of a drab color, compact, and rather earthy in appearance, incapable of taking a high polish, and possessing a characteristic appearance due to the presence of porphyritic crystals of a clear, glassy nature, and which become very prominent upon the smooth or polished surfaces. These glassy crystals are of calcite, and the forms of the fossils which are sometimes seen are filled with the same glassy material. The earthy ground mass, which constitutes the bulk of the rock, will not dissolve in dilute acid, and is of a dolomitic character, as is shown by the analyses that have been cited. The stones consist of irregular, minute grains, which are closely fitted together with rhombohedral crystals of dolomite developed among them. All of the sections when magnified show very numerous but exceedingly small particles of pyrites. This is what probably produced the 4 or 6 inches of sap or discolored rock adjoining the natural clefts.

The limestones quarried at Piqua, Miami county, are from the lowest horizon of the Niagara formation, (*a*) and are therefore the exact equivalents of the Dayton stone. They are immediately underlaid by the Clinton limestones, and the glacial action has plowed away the stones of the Springfield and Covington type which once overlaid them. The material here extracted is of good quality. The stone lands sometimes bring $2,000 per acre near Dayton, and their value is indicated by the circumstance that, although the stone is not more than 16 feet in thickness, it is frequently extracted in places where 20 feet of dirt and dritt must be removed from above it. The stone belonging to this horizon is usually very strong, specimens having been found to resist a crushing force of 30 tons on a 2-inch cube. The quarries are situated at and directly south of Piqua, upon the west side of the river, with the exception of one quarry 2½ miles south of the town. The material is sent by rail, canal, and team to the neighboring towns and cities of Ohio and Indiana, where it is used mostly for rough building purposes. No prominent structures have as yet been constructed from it. The thickness of the strata varies, and it is therefore possible to obtain slabs suitable for pavements. Indeed, it is claimed that slabs 20 feet square from some quarries are accessible. The town of Piqua is mostly paved with this stone, utilizing for this purpose the poorer and inferior layers. The walks would be greatly improved by the use of the better layers.

In the quarries immediately at Piqua about 2½ feet of the lowest layers are heavy and thick, and are used for bridge stones. Then follow about 7 feet of building stone, overlaid in one quarry by 1 foot of well stone and 2 feet of drift, and in the others there are 7 or 8 feet of drift to be removed. Quarries below the town are overlaid by 22 feet of drift, the lower portion of which is composed of fragments of broken limestone, of all sizes and shapes, piled together with an intermixture of gravel. This stone, like the Dayton stone, is mainly composed of calcium carbonate, which, it is said, usually constitutes over 90 per cent. of the whole. That it varies, however, between quite wide limits is shown by the circumstance that of the two specimens sent on one is quite dolomitic, and will dissolve but little in dilute hydrochloric acid. It contains streaks and clear crystalline spots, which are of calcium carbonate, and under the microscope in minute structure it is found to contain more or less of sharply-defined crystals, which are probably of dolomite. The stone in some of its layers contains more or less of pyrites, and is mainly of the variety which is called blue limestone. Some of it will receive a tolerably fair polish, and when thus treated it has a prettily-mottled structure, or a gray- and white-banded structure, according as the blocks are polished upon a plane parallel or perpendicular to the stratification.

The Dayton limestone is an evenly-bedded, massive, gray carbonate of lime, which is sparingly charged with fossils, and which is quarried from the very lowermost courses of the Niagara formation. It is found in firm, heavy courses that are at times 10 feet in thickness, though often very much less. So-called cutting stone is obtained from these beds. This term "cutting stone" is generally employed to designate stone which comes out in large blocks suitable for steps, platforms, etc. Cutting stone is sharply distinguished from building stones in all the quarries of western Ohio, and brings several times the price per cubic foot. The thinner and inferior strata serve a great diversity of uses.

Although stone of excellent quality occurs in various portions of Montgomery and Greene counties, the market has been thus far largely supplied by the quarries situated in the neighborhood of Dayton. Five quarries have there been opened in a belt which lies a mile and a half east of the town, whose sections exhibit 5 feet of the so-called cutting stone, overlaid by from 10 to 18 feet of drift. They produce all kinds of building stone (graded in from three to six grades), which is mainly sent to Dayton and to Cincinnati. The court-house and some of the churches in Dayton were constructed of this stone.

Another quarry in this same horizon, situated 7½ miles north of Dayton, has only 5 feet of drift to be removed; but, on the other hand, the thickness of the stratum of cutting stone is least in this quarry. The court-house at Sidney, Ohio, is built of this stone.

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a Geological Survey of Ohio, Vol. III, Part i, p. 468: "Geology of Miami County," by John Hussey.

At a quarry operated 6 miles east of Dayton the deposit consists of 4 feet of cutting stone, overlaid by 6 feet of a yellow-colored stone, the whole capped by 9 feet of drift. Two miles farther to the east lies a quarry which contains 4 feet of cutting stone overlaid by 3 feet of drift. The last two quarries are in Greene county.

Quarries have been opened in the same stratum of stone in the neighborhood of Xenia, and these have been widely known and extensively worked. This is in fact one of the three localities to which the contracts for the foundations of large works in Cincinnati were formerly confined, the specifications calling for Xenia, Centerville, or Dayton stone. This is the easternmost exposure of the last-named stone. The Dayton limestone is a peculiar and exceptional member of the great Niagara series in southwestern Ohio. It lies in lenticular masses of comparatively small extent, perhaps not more than two or three square miles occurring in any one area. Throughout Montgomery and Greene counties the shale, which forms the next succeeding layer of the Niagara formation, has in almost all cases been removed by erosion, and thus it happens that the stone is immediately covered with the deposits of bowlders, clay, and dirt, as described. The glaciers which have produced this result have polished and striated the rocks in many cases.

The composition of the Dayton limestone is shown from the following analysis, made by Dr. Locke in 1838: (*a*)

	Per cent.
Calcium carbonate	92.40
Magnesium carbonate	1.10
Iron protoxide	0.53
Insoluble material	1.70
Soluble silica	0.90
Water	1.08
Total	97.71

The stone from the McDonald quarry, near Xenia, has been analyzed by Professor Wormley, (*b*) with the following result:

	Per cent.
Calcium carbonate	84.50
Magnesium carbonate	11.16
Alumina and iron oxide	2.00
Siliceous matter	2.20
Total	99.86

When examined under the microscope these stones, as illustrated by the samples sent, are found to be composed largely of fossil fragments, which are so broken and destroyed as to be unrecognizable to the unaided eye. These fragments are united by an extremely fine ground mass, in which here and there a sharply-defined rhombohedral form is porphyritically developed. These porphyritic crystals are quite prominent in the stone from the Huffman Stone Company's quarry, near Dayton. A section of this stone was treated with dilute acid, when everything dissolved with the greatest facility, with the exception of these porphyritic crystals, which may consequently be supposed to be rhombohedrons of dolomite which have developed themselves in the mass of calcite.

Although stones of such excellent quality are obtained from the Dayton beds, it is necessary to mention that stones occur in which pyrites exist in large crystals at least half an inch square. Pyrites is recognizable in the thin section of all specimens sent to us, though this ingredient is not so disastrous in a stone of this nature as it is in other more porous stones, in which the pyrites would not merely be reached much quicker by the decomposing agencies, but in which the products of decomposition would more quickly find their way through the cracks and crevices of the stone. The material has attained a high reputation. It was used at one time extensively at Chicago, and the lowest story of the Chamber of Commerce edifice is built of it. Cincinnati has used it largely, but for the last 15 or 20 years it has not been shipped so extensively to these points.

Beds of the Dayton limestone are developed in Clinton county. They have been quarried at Wilmington and Centerville, but the old quarries which have been reported as in active operation during the census year are situated 1¼ miles southwestward from Lumberton. The quarry consists of 5 feet of stone, which is mostly used for rough building purposes, and is overlaid by 2 feet of drift. The material is hard, very compact, and capable even of assuming a quite high polish. It is also very noticeable that the rock, which to the unaided eye appears so compact and non-fossiliferous, really contains a very great number of fossil fragments. It also contains some pyrites, distributed through the mass in the form of very sharply defined cubical crystals, which in the specimens sent are entirely invisible to the unaided eye, and which cannot be called deleterious. There are yellowish spots and streaks in some of the layers, but this appears to result from the inclusion of clayey material rather than from the oxidation of the iron sulphide. The stone from this quarry finds its market principally in Clinton and Fayette counties.

The rocks in Clarke county (*c*) are like those found in Montgomery and Greene counties, but the important quarrying operations are all carried on in the upper beds of the Niagara formation, which are typically developed

a Report of Progress upon the Geological Survey of Ohio, 1869, p. 152.

b Geological Survey of Ohio, Vol. II, Part i, p. 669.

c Geological Survey of Ohio, Vol. I, Part i, p. 450: "Geology of Clarke County", by Edward Orton.

at and about Springfield. These beds are of particular value, as they possess a greater thickness than any one of the underlying formations in the county, and cover a much wider area. In the same quarries building stones of excellent quality are combined with material that is converted into peculiarly excellent lime. The accompanying section of the rocks at Springfield indicates the relationship of the beds.

The underlying shale occupies the position of the limestone which is quarried so extensively at Dayton and at Piqua. The overlying beds of building stone have given the name to the so-called Springfield division of the Niagara, and the less compact layers of the overlying so-called Guelph formation are broken up and burned.

The Springfield building stone is a carbonate of lime and magnesia, containing only small percentages of silica and alumina. Its usual color is a light drab, although blue and yellow courses occur. The light-colored stone sometimes is defaced by faint reddish streaks which are caused by the presence of iron oxide, and which render the stone unfit for some of the finer uses. The thickness of this deposit of building stone is not more than 20 feet, and is usually less. The lowest courses are blue in color, and although massive in appearance, they sometimes prove treacherous as building stones, for they are liable to lose their dressed surfaces, while their seams widen and they undergo a slow disintegration. The walls of the jail in Springfield furnish an illustration of these characteristics. The drab courses are almost all of durable building stone, and furnish an invaluable supply of building material for Springfield and the adjacent country.

The difference between the blue and the yellow courses in most of the limestones of Ohio appears to depend upon whether the iron exists as pyrites or as oxide of iron. The pyrites existing in a fine state of subdivision appears black even under the microscope, and the blue color of the stones apparently disappears with the oxidation of the pyrites. This furnishes an illustration of the circumstance that stones are often improved by decompositions which take place inside the beds, for if their value is not thereby destroyed there is much less danger of a disintegration by a decomposition of the quarried stones.

From quarries within 1½ miles west of Springfield the material for the culverts in the state road were obtained, and the material for the bridge at Marysville and for the Masonic hall at Urbana. These quarries are known as the old state quarries, because the material was used in many constructions on the state road. The quarries are large, but the stone from them is used chiefly in building cellar walls, foundations, and other rough work of a similar nature.

Two miles west of Springfield are situated four quarries which furnish similar stone, that is used in Springfield, Dayton, Urbana, London, and Marysville. In all of them the cap-rocks are burned into lime, and the larger portion of the profits results from its sale.

In all cases it is the overlying Guelph beds which are burned, as the courses of building stones contain a considerable percentage of silica and alumina, and cannot be converted into good lime, although some of this material makes a fair cement. The lime product of these quarries finds its way in small quantities as far as New Orleans. It is mild, cool, and strong, and also very white. There is no trouble in laying seven bricks with one spreading of mortar, and skillful workmen can lay twelve bricks with one spreading. The superior quality of this lime is worthy of note, since it is ordinarily considered that the value of lime is diminished by the presence of magnesia.

The composition of the Springfield limestones is shown by the following analyses of the middle and upper beds in Mr. Frey's quarries near Springfield. These analyses were made by Professor Wormley for the *Report on the Geological Survey of Ohio*: (*a*)

	Middle bed	Upper bed.
Calcium carbonate	54.70	54.70
Magnesium carbonate	44.93	42.37
Alumina and iron sesquioxide	0.20	1.00
Siliceous matter	0.10	1.50
Total	99.93	99.57

It is thus seen that the rocks are very nearly typical dolomites. They vary somewhat in composition, but not so as to at all influence their value as building stones. They possess an open and porous structure, and are incapable of assuming a polish or being used for ornamental purposes. In their microscopic structure they are seen to be of the crystalline granular type, the fossiliferous character being obliterated from the microscopic structure, although fossils are not rare in the rock.

The Yellow Springs quarries produce a magnesian limestone which is very easily worked, and the larger part of which is durable. These quarries are upon the same horizon as the Springfield quarries, and produce stone of the same nature. The courses vary in thickness from 4 to 14 inches, and some of them answer very well for cutting stone. The same qualified commendation can be given to them for flagging, but the quarries have not been extensively developed with the end in view of producing this material. For general masonry the stone has proved very serviceable, and for economy is not surpassed by any stone in the state. There are two colors, which are obtained from different courses, and which are denominated as blue and drab; the blue courses weather to drab in exposed

a Geological Survey of Ohio, Vol. I, Part i, p. 474.

places, but it is not certain that all of the drab beds have been made by oxidation of blue layers. The blue beds sometimes prove treacherous, and even the firm and massive appearance of the stone furnishes no safe guide in judging of its power to withstand the atmosphere. By far the larger portion, however, is excellent in this respect, and the drab courses are almost without exception satisfactory.

Three-quarters of the gross earnings of these quarries are, on an average, obtained from the sale of lime, sent to market under the name of the Springfield lime, which is the standard for southwestern Ohio.

A section of the quarry shows at the bottom some layers of building and cutting stone, above which is a 10-foot bed of solid limestone containing pentamerous fossils, and above are 18 feet of the "shelly" limestone, which is burned. The principal quarry at this place produces stone for bridges, steps, and sills, which are principally used in the vicinity of Yellow Springs. The composition of the stone from this quarry is indicated by the following analysis by Professor Wormley: (*a*)

	Per cent.
Calcium carbonate	51.10
Magnesium carbonate	41.12
Sand and silica	5.40
Alumina, with a trace of iron oxide	1.40
Total	99.02

The quarries in Miami county resemble those at Springfield, and are located in the same geological stratum. They are rendered valuable by the circumstance that for 50 miles in some directions there is no other developed quarry. To the northeast, north, and northwest the region is heavily buried under beds of drift, and consequently building stones are inaccessible. The material from the Covington quarries is distributed, therefore, very widely. The stripping is light, the drainage easy, the quantity and quality of the stone are both excellent, and great variety exists in the thickness of the various strata.

The Covington stone is chiefly used for building and bridge construction, and it is mostly consumed in Covington, Ohio, and Winchester and Marion, Indiana. Some bridges on the Pan-Handle railroad have been constructed from this material. At the town of Covington there are six quarries in active operation, as indicated by the table. Some of these must soon be given up, for they lie within the city limits, and houses are being now constructed in their immediate neighborhood.

The material resembles that which is quarried at Springfield in being porous and easily cut. Of the specimens sent to the museum one was blue and one yellow, and upon examination it was found that they differed not merely in the circumstance already mentioned, in that the blue layers contain unoxidized pyrites and the other hydrous iron oxide, but the blue specimen was a dolomite which would not effervesce in acids, while the yellow specimen was much more calcareous. In microscopic properties this stone presents no peculiarities. It belongs to what we have designated as the porphyritic type; that is, it contains rhombohedral crystals of dolomite developed in a mass of formless grains of calcite.

In Shelby county the upper portion of the Niagara formation is developed, and several quarries have been opened, the products of which are almost entirely burned into lime. Building stones can be there obtained at any time and in any quantity desired.

Hancock county is occupied by rocks of the Niagara and Helderberg periods, and although the Niagara rocks which from here extend in a narrow strip northward to lake Erie appear to be separated from that great area of Niagara rocks in which the Springfield and Dayton quarries are situated; they probably extend beneath the Helderberg rocks that intervene and form a portion of the same deposit. The rocks quarried at Findlay possess characters almost identical with those of the Springfield stones. They possess a rather porous and open structure, are drab in color, and occur in courses from 3 to 12 inches in thickness. The stone is strong and durable, and none of it has as yet shown any bad effects from exposure to moisture or frost. It is rather hard to dress, and stone-workers call it "plucky". The horizontal surfaces are generally roughened by small angular prominences which fit into corresponding depressions in the superimposed layer, forming the structure which is known as "suture" jointings. The dip here is very slight, and the top course in all of the Findlay quarries is evenly bedded and about 1 foot thick. The "seams" (open joints) are from 25 to 100 feet apart, and those joints usually run at right angles to these seams at greater or less intervals. For this reason, if the quarry is stripped over a sufficient space, the rock can be obtained without blasting. The material from these quarries is used for foundations of buildings and for bridge abutments in the county, and last year some was shipped to Seneca and Allen counties.

In composition the stone from the Findlay quarries is dolomitic and possesses the characters of the upper Niagara beds. In microscopic structure it is beautifully crystalline, the whole mass of the rock being made up of an aggregate of more or less well-defined rhombohedral crystals.

It appears that blocks much larger than can possibly be required are obtainable here, and that the material, although at present used only for rough construction, could be safely applied as a building stone. Although the present quarries have been opened quite recently along the same streams upon which these are situated, and within a short distance of them, quarries have been in operation for more than twenty years.

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a Report of the Geological Survey of Ohio, Vol. II, Part i, p. 672.

HELDERBERG.—The Helderberg formation is exposed in a narrow strip (*a*) upon the boundaries of Highland and Ross counties, and indeed more stone is taken from the quarries at Greenfield than from any others in the Helderberg formation of Ohio. The stone is regular in its bedding, and, therefore, curbings and crossings of excellent quality are easily extracted. In the Cincinnati market it is largely employed for these purposes. Slabs 3 or 4 inches thick, with a superficial area of 4 feet, can be obtained with surfaces as smooth and regular as if sawed. These stones can be used for door-steps and like purposes without any dressing. The courses are never heavy, seldom exceeding 14 inches, and usually ranging between 4 and 8 inches in thickness. The stone is exceedingly strong, 2-inch cubes having been found to stand a pressure of over 50,000 pounds. The quarries produce no waste material, and their spalls are saved to be burned into lime of fair quality. Perpetual kilns are set upon the edge of the Greenfield quarries, the floors of which are kept clean and free from accumulations of refuse of any kind, and the lime produced is similar to that obtained from the Niagara formations, but it possesses in some degree hydraulic properties which make it especially adaptable for outside work.

The stone produced is drab in color when first raised, but upon exposure it generally acquires a yellowish-brown shade. It is ordinarily used only for the rougher purposes of construction and for flaggings and curbings, but, by proper selection and skillful dressing, stone can be obtained from the quarries that produce a good architectural effect. Without such an exercise of taste and judgment, the stone does not appear well, owing to its monotonous gray color, which contrasts unpleasantly with the white lines of mortar. On the other hand, its regular bedding renders it peculiarly suitable for ordinary purposes, as it can be laid upon its even bed surfaces easily, and therefore can be worked with facility and economy. The stone finds its principal market in Cincinnati.

It will be noticed that of the large quarries which supply the Cincinnati market but one is in Highland county. The other is situated in the town of Greenfield, in Ross county. In the Highland County quarry one-twentieth of the profit results from the sale of lime, but in the Ross County quarry more than one-half is burned.

In the Ross County quarry the section shows 42 feet of stone disposed in layers, all of which are available. The quarry is capped by 10 feet of drift material, which constitutes all of the stripping. The Highland County quarry shows 35 feet of stone of a like character overlaid by 6 feet of drift.

The stone in the main is non-fossiliferous, but upon the surfaces of a few layers there are found the forms of the *Leperdita alta*, which is a characteristic fossil of the Helderberg formation. A layer of concretions from 1 inch to 3 inches in diameter is found in the upper part of the section, and short cylindrical columns which fall out, leaving cylindrical cavities in the stone 3 or 4 inches in diameter, occur in considerable numbers, and which are supposed to be due to the effects of pressure.

Nodules of zinc-blende are not uncommon in the Greenfield stone, and the fossil corals are sometimes composed of silica, which also is distributed through some of the stone in bands that separate the layers.

In composition the stone is nearly a typical dolomite, as is indicated by the following analysis: (*b*)

	Per cent.
Calcium carbonate	53.67
Magnesium carbonate	42.42
Alumina and iron	-----
Sesquioxide	1.30
Calcium and magnesium silicates	1.44
Silica	1.00
Total	99.83

When examined under the microscope the whole stone shows the characteristic crystalline granular structure of the Helderberg formation. There are streaks of iron oxide and carbonaceous matter which proceed in regular wavy lines through the sections, and these bituminous substances are what give to the stone the strong fetid odor which is produced by striking or cutting it. The quality of the lime produced is another evidence that magnesian limestones may be converted into lime of excellent quality.

Quarry operations have been carried on at Greenfield since the first settlement of the country to satisfy the local demand, but in recent times the business has been greatly enlarged for the more distant markets along the line of the railroads, and especially for the Cincinnati demand. The supply of stone is practically inexhaustible.

In the southern and western part of Champaign county the Helderberg or Water-lime rocks have been quarried in numerous places; formerly a quarry at Salem supplied most of the local demand, and the building and flagging stones used in Urbana were obtained there until the sandstone of Berea superseded them. The stone obtained in the neighborhood of Urbana is of indifferent quality for building purposes, but here it is found in a drift-covered region in an area which for 25 or 30 miles in each direction is devoid of stone. Only about 14 feet of the upper strata have been much quarried. The floor has been sunk to a greater depth, and the stone from the lower courses is proving itself to be a valuable building stone for rougher work. There is no so-called cutting stone in the quarry,

a *Geological Survey of Ohio*, Report of Progress in 1870, p. 255: "Geology of Highland County," by Professor Edward Orton.
b *Report of Progress of Geological Survey of Ohio*, 1870, p. 287.

and the accompanying section will give an idea of the method in which the strata of the Helderberg are arranged at this point. It will be noticed that there is much greater diversity as regards stratification than is shown in the Greenfield quarries.

The specimen sent to the National Museum is a light drab stone, somewhat streaked with red. Its material is of the same character as that of the other Helderberg stones—that is, a dolomite with a fine, crystalline, microscopic structure, and which emits a bituminous odor when struck with a hammer, although the odor is not so strong as in the case of some other Helderberg rocks.

Allen county is almost entirely covered by limestones of the Water-lime or Helderberg formation, (*a*) and all of the quarries that have been considered worthy of note extract stone from these beds that is used for the more ordinary building purposes and for foundations and underpinnings. The upper beds of the Niagara formation occur in the southeastern corner of the county, and a few quarries were once opened in those rocks, but the building material that was extracted was inferior, and the production of quicklime from them was not profitable.

Although the building stone obtained from the Helderberg is, as a rule, not of excellent quality, still, as it is the only accessible material, it is of much value.

The stone quarried directly in Lima is an inferior building stone, and is seldom used for foundations above ground, but is in demand for the underground portions of foundations. The quarry is worked more to obtain stone for macadamizing than for any other purpose. It occurs in thin layers, and a block 6 inches thick is seldom obtained. This thinly-bedded character renders it applicable as a flagging stone; the bedding, however, is uneven.

The material obtained from this quarry is a dark gray dolomite, which is quite porous in its character; it dissolves in hot acid with very little residue, and the solution is found to contain only traces of iron oxide, which the microscope proves to exist in the state of pyrites. The polishing of a face upon this stone renders its fossiliferous character very prominent, which is not common in the rocks of this formation. The stone is very bituminous and gives forth a foul odor when struck with the hammer.

A quarry 4 miles north of Lima is said to produce some material of a much better quality. It is situated near the Dayton and Michigan railroad, but a side track could not be constructed to it without considerable expense on account of the heavy grading that would be necessary. Some of the courses are over 1 foot thick, and some from 4 to 6 inches thick have been used for sidewalk paving in front of the Lima machine works, where it gives indication of both strength and durability. The following is a section of the strata in the quarry:

	Feet.
Soil	3
Building stone for ordinary foundations	3
Dark gray paving stone	1½
Blue shaly material	—
Blue-stone	—

There is no natural drainage below the paving stone, and for this reason the underlying blue-stone has not been extensively quarried. According to the testimony of all builders and contractors the stone in the bottom of this quarry is the best building material found within a radius of at least 30 miles. The shaly rock which overlies the blue-stone forms good material for the macadamizing of roads. The material above the paving stone, which is used for foundations, occurs in thin beds which are never more than 3 inches in thickness.

The specimen which was sent from this quarry was taken from the lower or "blue-stone" layers; it has a dark gray color, finely banded with yet darker lines, and much more compact than most of the stones sent from the quarries in the Helderberg. Indeed, no pores or cavities were found in it, and its texture was such that it admitted of a fair polish, as indeed do most of the Helderberg limestones. The stone from this quarry is a dolomite, but on being dissolved in hot acid quite a large residue of argillaceous character is left undissolved, and it contains bituminous substances which impart to it the character of a fetid limestone. It contains little or no iron.

A quarry is situated 5½ miles northeast of Lima, and the following section indicates its character and the uses to which the stone is applied:

Stripping	feet	5
Road stone	do	3
Gray building stones	do	3
Two courses of blue-stone	inches	6
Blue clay	do	½
Gray building stone	do	—

As in the case of the preceding quarry, the thickness of the stratum of the gray building stone is as yet undetermined. It occurs in courses from 3 to 6 inches thick. The upper 3 feet of stone, which is used for the purpose of macadamizing, is extracted with neither profit nor loss. The material is a more or less porous dolomite of a gray color, mottled and streaked with black, which is due to the arrangement of the bituminous substances contained in the stone. Of the two specimens sent to the National Museum, one was polished upon a surface parallel with the stratification, and this treatment developed a beautiful structure, due to the presence of

a Geological Survey of Ohio, Vol. II, Part i, p. 397: Report on the "Geology of Allen County", by N. H. Winchell.

a fossil bryozoan, which filled the layer that was cut. Thus the presence of a fossil in abundance was demonstrated although the rough stone gave no indication of a fossiliferous character. This stone and the one previously described from Lima are the only stones of a fossiliferous character which were sent to the Museum, and which were obtained from the Helderberg formation.

These stones are thus most markedly contrasted with those from the Niagara, which are almost all fossiliferous, as is indicated by microscopic examination, which very often renders the forms evident when they are invisible to the naked eye.

In the eastern part of the township of Bluffton the quarries are better adapted to supplying flagging than building stone, since the thickness of the strata usually varies from 1 inch to 3 inches. When properly laid down these slabs make a very durable paving material for sidewalks, cellar bottoms, etc. They are very hard, but break quite easily into any required shape. The stone is dark-colored and of the same character as those previously described. Its color is imparted to it by bituminous substances, and the dark streaks with which it is filled are very irregular, so that a pattern not at all unattractive to the eye is developed upon the smooth or polished surfaces of the blocks, and when dressed in the usual way and laid with white mortar they make a beautiful wall for smaller buildings. Such large blocks have been moved as to insure the possibility of obtaining blocks as large as might be desired.

Although the quarries described have been recently opened, the stone has been quarried in the immediate neighborhood for fifteen years.

Scott's Crossing is situated 4 miles east of Delphos, on the Pittsburgh, Fort Wayne, and Chicago railroad. A quarry at this place produced a drab-colored limestone, which occurs in courses from 3 to 11 inches thick, and which serves very well for foundations. Samples which have been in walls for over fifty years show no signs of decay. The quarry is situated in the bed of the Auglaize river, and is not worked early in the spring nor late in the fall, when the water is high. A slight dam is built about the quarry, which is washed out every winter, and in addition heavy rains in the summer frequently destroy the works. No more permanent dam is built, since the site of the quarry is often changed, and no excavation has been made in the vicinity to exceed 6 feet in depth. The material is mostly used in the vicinity for bridge abutments and at Delphos for foundations for buildings. It has been sent, to a limited extent, into Mercer county, over the Toledo, Delphos, and Birmingham railroad, to localities where the Piqua stone is not so readily sent. Ten inches of coarse sand, gravel, and other river deposits cover the stone, and about 18 inches of the cap-rock is used upon the public highways. This is one of the best building stones quarried in Allen county for the purposes to which it is applied.

Van Wert county is covered in its northwestern part by the Niagara beds. The Helderberg limestone underlies the rest of the county, but only a few exposures of the rock of either kind are known, as the whole region is mostly covered by drift. (*a*) The county is entirely agricultural, and the stones where quarried furnish materials that are used only for foundations in that neighborhood or burned for lime. The lime-kilns at Straughn have caused the most extensive quarrying operations, and the Helderberg stones there extracted are said to burn easily and cheaply to a beautiful white lime. The Van Wert quarry, which is the only one reported as producing any considerable amount of building material, also produces quicklime; and during the last census year the value of the lime produced was about equal to that of the building stone. The Van Wert stone is a light gray dolomite, which is found in courses from 3 to 7 inches thick. The material thus far has given evidence of being a good building stone. Openings have been made in the limestone at several other points in the county; for example, on the Little Auglaize, in the northeastern part of the county, a stone very much like the Bluffton limestone has been quarried to a small extent for the Delphos market. In the northwestern part of the county some building stone is said to have been obtained in much thicker courses than in any other part.

A very light gray limestone has been quarried at Charloe, on the Auglaize river, in Paulding county, which belongs to the Corniferous formation. This Paulding limestone is a soft stone which occurs in courses about 3 feet thick. It has been sawed, and was used in the foundation of the court-house and also in that of the Russel House at Defiance, where it has suffered from the action of moisture and frost. As other specimens of the same stone do not show this disintegration, its defective character is very likely due to the circumstance that it was quarried too late in the season. A blue limestone is also quarried about 5 miles farther down the river from Charloe, which occurs in courses from 6 to 18 inches thick, and has been used for the construction of locks on the Miami and Erie canal. It is not durable when exposed to atmospheric action, and the quarries have been abandoned. The demand for the material has been destroyed by the introduction of the White House stone from the north and the Piqua stone from the south.

Tiffin is situated exactly upon the boundary between the Niagara and the Helderberg rocks, in Seneca county, and its quarries, although producing only Helderberg rocks, show at some times at their bases exposures of the underlying Niagara limestones. These quarries are located on the eastern side of the ridge known as the Cincinnati axis, and the characteristics of the rocks are much the same as those in the quarries on the western side of the anticlinal in the Helderberg formation; but the stones at Tiffin are more massive, and are therefore more suitable

(*a*) *Report of the Geological Survey of Ohio*, Vol. II, Part 1, p. 344: "Geology of Van Wert County," by N. H. Winchell.

for heavy construction. The courses are often 2.5 inches in thickness, and the stones produced are used largely for foundations and bridge work. The product of quicklime from these quarries is also large.

The stone is light drab in color; it is bituminous, and gives forth a strong odor when hammered, but this characteristic is not so marked as in the dark colored varieties. The principal market for all three of the quarries situated in Tiffin is furnished by the immediate neighborhood. Beside the quarries in the table there are several smaller ones which are worked in the vicinity of the town, and which produce the same kind of material in less amount.

A short distance west of Fremont several quarries have been opened in the strata of the Water-lime or Helderberg formation.

The only quarry at this point of sufficient importance on account of its production of building stone is situated one mile to the west of Fremont, and in this the value of the lime which was produced from the quarry during the census year was ten times that of the building stone. The strata suitable for building purposes are from 1 foot to 10 feet in thickness, and the material which does not make an excellent quicklime is comparatively small. As a building stone the material is superior to much of that used in counties to the southwest, although not equal to the Sandusky and Marblehead limestones. It is of a light drab color, full of small cavities, and works very easily, and some of it is soft and pure enough to be sawed. The stripping is sold for macadamizing. It presents the usual microscopic characteristics of the Helderberg rocks, and it dissolves in hot acid, leaving a very slight residue. The qualitative analysis indicates that it is composed of remarkably pure dolomite.

CORNIFEROUS.—Quite a variety of stone is found in the neighborhood of Columbus, for although Franklin county is flat it has a number of geological formations within its limits. To the east lie the Waverly sandstones and the Huron shale, but the limestones of the Corniferous, which lie to the west of Columbus, are by far the most important from an economic standpoint. Thick and heavy layers of stone exist among the strata. From the different layers material suitable for the most diverse uses can be obtained, good quicklime can be made, and being in part a very pure carbonate of lime the stone is desirable as a flux for smelting iron ores. Of late it has been very extensively applied to the latter purpose, especially in the Hocking Valley region. The quarries are all situated a few miles to the west of Columbus, and have been operated for a long time. Some which have been the most important, for instance the state quarries, from which the material for the state-house and for the walls of the state-prison was extracted, are no longer worked, but all of the quarries mentioned in these tables are immediately about the old quarries and extract the same material. While the state-house was in process of construction, and stone of the best quality was in demand, the Corniferous limestone was worked to a greater depth than it is at present, for the finest quality of stone is found in the lower layers. At present the production of building stone is subordinate to the production of lime and flux.

The Columbus limestone is dense, compact, and strong. There are 12 feet of the upper courses in the present quarries that average 93 per cent. of carbonate of lime, and frequently the percentage rises to 95 or 96, while, on the other hand, there are localities where the Corniferous limestone becomes nearly a typical dolomite, as at Bellefontaine. The stone is fossiliferous, but the fossils are very firmly cemented and do not appear to weather out; in some cases, indeed, the fossil appears to be firmer than its surrounding stone. In microscopic structure the stone bears the appearance of a fragmental stone, being composed almost entirely of fragments of fossils. In the finer ground mass very perfect little rhombohedrons of dolomite are developed, which in number are apparently disproportionate to the amount of magnesia contained in the stone. Many of the fossils have apparently retained their primitive condition, but others have been dissolved away and the forms filled with crystalline calcite; and this will perhaps explain the different behavior of the fossils in weathering. The stone is somewhat bituminous in character, as evinced by the odor emitted when struck. Its gray color is pleasing to the eye; it works easily, and will even assume a good polish.

Dynamite is used as an explosive to a large extent, any desired number of charges being exploded simultaneously by means of electricity.

Although the common stone for foundations and underpinnings used in Columbus is obtained from the quarries, still, during the census year, no great amount of building stone was extracted, and no important structures were built from the material. The quarries can at any time be operated much more extensively, and will produce a superior quality of stone for fine construction.

In the eastern half of Logan county a large island of Corniferous limestone occurs, the center of which is covered with shales, but all around the edges small quarries have been opened for the purpose of obtaining stone both for building purposes and for lime.(*a*)

At the present time the only quarries of special importance that are located in this district are those which are situated a short distance to the northwest of Bellefontaine, and the material which they produce is used chiefly for rough work. Although capable of producing excellent building material, the more important stone structures in the neighborhood have been built of materials brought from a greater distance. The quarry operations are carried on in a quite primitive manner, and at present the lower strata in one quarry are inaccessible, since no means of

a *Report of the Geological Survey of Ohio*, Vol. III, Part 1, p. 482: "Geology of Logan County", by Franklin C. Hill.

drainage have been supplied, and the quarry is filled with water to a depth of from 12 to 15 feet. The top layers of the stone are being extracted, although the lower layers are best suited for purposes of construction.

The quarry of Angel, Miller & Co., situated a half mile west of Bellefontaine, exhibits the following section:

Drift	feet	5
Cellar stone	do	10
Heavy hard stone	do	5
Honey-combed porous stone	inches	9
Heavy soft stone	feet	5

Occasionally some lime is burned at this quarry, although its amount is small and its quality inferior.

The material that is at present produced by these quarries is a typical dolomite, and in microscopic structure consists of a perfect mass of sharply defined large rhombohedral crystals of dolomite cemented together by a mass of minute little crystals of the same form and composition. In many places the crystals are only attached at their corners, leaving angular interspaces, and this accounts for the avidity with which water is absorbed by this stone. The fossiliferous character, if any originally existed, has been entirely obliterated. In color it is light gray, and it works easily and safely. Its microscopic structure is illustrated upon the plate at the end of the chapter.

The first quarry in Marion county was opened in 1825 in what is known as the Marion limestone. Ten acres only are considered as belonging to the quarry. It is situated in the southeastern part of the town of Marion, and is the farthest south of any quarry in the neighborhood producing good building stone. A gray stone occurs about 12 or 14 feet below the surface, and is probably underlaid by blue-stone, but as the gray is considered the best the lower courses have not been opened.

Other quarries are located in the northeastern part of the town which extract material for building and quicklime. The largest quarries are, however, operated on the Columbus and Toledo railroad, one mile north of Marion. The stone is considered very strong and durable. The average thickness of the rocks extracted is not more than 8 inches, although blocks 12 and even 15 inches thick are sometimes obtained. There is no difficulty in extracting blocks of any required dimensions in the bed for all ordinary purposes of construction. The stone is easily quarried, being lifted with bars and broken with sledges, no blasting operations being necessary except to make an opening in the floor of the quarry for deeper workings.

The material is chiefly used for foundations and bridge work, and was largely employed in the construction of the depots and shops of the Columbus and Hocking Valley railroad. It is commonly called blue limestone, although the color differs at different horizons, and the layers also vary in texture and hardness, each layer, however, being homogeneous. The stone is usually quite fine in grain and rather hard. The following may be regarded as a typical section representing this and all other quarries in the neighborhood of Marion:

	Feet.
Soil	1 to 4
Weathered rock	1 to 4
Blue-stone	1 to 6
Gray-stone	4
Blue-stone	

The overlying blue-stone is found in blocks from the exterior of which a gray color penetrates to a variable depth from the natural joints. It is liable to contain flinty nodules, from which the underlying gray-stone is almost entirely free. The blue-stone in the bottom of the quarry is free from this gray covering; but the intermediate stone, which is all gray, is considered the best material.

In these quarries the gray-stone is found near the top, but in the other quarries reported from this township, being about 1½ miles to the southeast of these, and in the direction of the dip of the strata, this gray layer is not struck until a depth of from 12 to 16 feet from the surface is obtained. A very large amount of the cap-rock has been used for macadamizing streets and for ballast on the Columbus and Toledo railroad. The quarries in this township furnish the greater part of the stone used in the northern part of Union county and in quite a large portion of Hardin county.

The material quarried at Marion is dolomite, containing some calcite. When microscopically examined it is found to consist of a multitude of perfect little rhombohedral crystals, each one of which contains a little black bituminous substance accumulated in its center, and all are cemented together by the calcite, which, although crystalline, does not assume a definite outline. The rock, when treated with cold and dilute acid, effervesces for a while, and the residue when examined is found to consist of a multitude of perfect and beautiful little rhombohedrons. The Marion stone has been selected for representation in the plate of microscopic sections, and some further remarks concerning its chemical composition and structure will be found in the general remarks that close this chapter.

At Owen's station, in the southern part of the county, there is a quarry in the Corniferous limestone from which over 9,000 tons of lime and broken stone were shipped during the census year.

Six miles northeast of Marion, in the township of Grand Rapids, the same limestone is worked quite extensively. A ridge occurs at this point in which a number of quarries are located.

Crawford county is well supplied with building material. The limestones are quite well adapted for construction of foundations, but they are not at the present time extensively quarried owing to a number of causes. There are

no great demands for stone in this agricultural region, and the home resources are thrown into competition with the Berea grit, which is quite extensively quarried at Leesville, in the southeastern part of the county. In Holmes township, about 6 miles northwest of Bucyrus, and near the Ohio Central railroad, three quarries are at present worked in the Corniferous limestone. The material has much the appearance of the Marion limestone, but, while it may be of the same quality, the courses are generally thinner and not so well bedded.

In Lykins township the same limestone is also quarried to some extent. The material from all these quarries has been used for bridge building and for foundations, but it is more and more displaced by the Leesville sandstone, especially for bridge-building purposes.

A large quantity of quicklime has been produced here which has been shipped from Nevada, in Wyandot county, by the Pittsburgh, Fort Wayne, and Chicago railroad.

For building purposes the limestone which is quarried from the Corniferous formation at Bloomville, Seneca county, has a higher reputation than the Helderberg limestones, and indeed it is said that these quarries produce one of the best limestones in northwestern Ohio. The material has been quite extensively used in Tiffin for many years for trimmings and stone fronts, and also for general building purposes in Mansfield and in the surrounding country. Good material for flagging, bridges, and foundations is quarried, and a slab 25 feet square might be obtained. It has already displaced in a measure at Mansfield the sandstones which are quarried in that vicinity.

The specimens sent to the museum are of an attractive gray color and are highly fossiliferous. Some fossils have apparently been entirely removed at some period and their places subsequently supplied with a clear crystalline calcite, and some of the fossil forms are therefore strikingly apparent upon polishing the surface of the stone.

Under the microscope the stone is found to consist of a grand aggregate of fossil fragments, among which here and there the rhombohedron crystals of dolomite are developed in much perfection. The number of these rhombohedral crystals is, as usual, proportionate to the amount of magnesia in the rock, which in this case is about 16 per cent.

The limestone industry in and about Sandusky is one of the most extensive in the state. This is partly due to the abundant and excellent supply of building stone furnished by the Corniferous strata of this region, and partly to the facilities for transportation by water and by rail. The city of Sandusky is founded upon a ledge of limestone, and excavation of any kind necessitates quarrying operations. In early days the stone thus extracted was the cheapest building material accessible, and came to be used very extensively. As a result the use of stone is more general there than in any other Ohio town.

At Sandusky the upper layers of the Corniferous formation are composed of a blue limestone of a thickness from 20 to 25 feet. This is underlaid by the white Sandusky limestone, which is found in thicker courses, cuts easier, and is capable of making a better lime; but at Sandusky this stratum, which is also from 20 to 25 feet in thickness, lies beneath the level of the lake, and is not readily accessible. The dip of the strata is, however, away from the water, and consequently this layer of white limestone is brought to the surface at Marblehead and on Kelley's Island, as is shown in a number of quarries. The largest quarries are situated at these points. Sandusky itself, owing to the circumstances mentioned, possesses quite a large number of quarries, and the city itself constitutes in fact a great limestone quarry covered with but a very shallow layer of soil or earth. These city quarries have been worked very largely for home and foreign supply, not less than 12 acres having been excavated to a depth of 8 feet. The Sandusky blue limestone is found in layers of convenient thickness, and the range work furnished by it presents an attractive appearance. The courses vary between 4 and 10 inches in thickness, and the material is used largely for flaggings, although not very well adapted for this purpose. It is laid in slabs from 4 to 8 feet square, which are not very smooth or regular until they become polished by wear, and then they are dangerously smooth. For construction purposes the stone has proven very durable, and the best foundations can be secured at small expense if made from this stone. It is also used for macadamizing the streets, and recently it has been found that a foundation of the Sandusky blue limestone can be advantageously overlaid by a thin coat of the white limestone which binds and cements the road-bed.

All of the quarries which in the tables are indicated as existing in the corporate limits of Sandusky are essentially one, as they produce the same material, and only in a single case has a quarry been sunk to the level of the underlying white limestone. About one hundred and eighty houses in the city have been constructed of this stone. The specimens sent to the National Museum from various quarries are identical in their minutes structures. They are bluish gray in color, compact, and present a fine appearance, however dressed. Although they effervesce rapidly in acid, they are quite magnesian, and under the microscope they are seen to consist of fossil fragments, among which a multitude of little rhombohedral crystals are developed. In the center of each one of these rhombohedrons is a black spot, which, upon close examination, is found to consist of pyrites. Sometimes, instead of a single spot, there is a large number of dust-like particles, which give to the stone a very marked and characteristic appearance. These are so numerous that it can scarcely be doubted that they impart the characteristic color to the stone. That they are situated, however, in the exact center of compact crystalline material cannot but have an influence in protecting them from disintegration, and there is no evidence that the presence of this ingredient has proved deleterious to the stone.

The white underlying limestone is what is called a cutting stone, and can be raised in blocks as large as can be handled. It is more highly fossiliferous to the unaided eye than the blue limestone, but under a microscope it is less so, and there is a much larger number of the rhombohedral crystals which correspond to its more magnesian character.

At point Marblehead the limestone quarries are all located in a terrace lying a few rods from the beach, where the thickness of the formation quarried is from 15 to 25 feet. Already 20 acres, as estimated, have been excavated to this depth.

These quarries are among the most famous of northern Ohio, and their location directly on the shores of lake Erie, and the heavy stones that some of them produce, have led to very large use of the stone, especially in the government works along the line of the great lakes. Latterly they are losing their place as building stones to some extent, but the production of lime has increased. Some quarries have been worked for at least fifty years. In these quarries the lower 6 or 8 feet are cemented into one solid sheet from which the large dimension stones for which the location is famous are extracted. It is from these quarries that a large part of the heavy stone used in the Sault Ste. Marie canal, in the northern light-houses, and in other government works has been derived. Many of the most important public and private structures in the region of the great lake were built of the Marblehead stone. The Detroit and the Cleveland water-works, the light-houses at Spectacle reef, Marblehead (built over fifty years ago), and Stanard's Rock, lake Superior, were all wholly or partly built of this material. It is particularly valuable in situations where it is exposed to the action of water or frost, as is shown by the condition of the old locks of the Sault Ste. Marie Falls canal and the light-houses in exposed situations.

The material from these quarries, like that at Sandusky, is a magnesian limestone, which contains beautifully-preserved fossils; the centers of the little rhombohedral crystals that characterize all of the Sandusky limestone are free from the grains of pyrites which characterize the blue Sandusky layers, and the difference in the color of the two stones is to be attributed to this circumstance.

The following analysis, made by Mr. J. Lang Cassels, represents the composition of the limestone from these quarries:

	Per cent.
Calcium carbonate	83.20
Magnesian carbonate	15.85
Silica	0.15
Organic matter	0.02
Moisture	0.80
Total	100.00

The proprietors claim that they could easily extract a block of stone equal in size to the Egyptian obelisk recently introduced into this country, its extraction being simply a matter of expense.

The block-stone proves to be a source of excellent lime, which has long been used, but which of late has been more abundantly produced. All of the waste material is devoted to this purpose, and nothing remains in the quarries except flint nodules. The modern kilns of the best construction are attached to some of the quarries, and 300 or 400 barrels per day are turned out from one single quarry. Part of the thin stone goes to lake Superior for furnace flux, where it is highly esteemed, and a large trade in the lime has been built up at Duluth and in the northwest, and the best stone of the quarries is now being burned. Much of the stone is shipped to other points to be burned, and all along the lakes are kilns which are supplied from Marblehead and Kelley's island. The Michigan Insane Hospital building at Pontiac and the government breakwaters at Erie were constructed of the Sandusky stone.

At White House, in Lucas county, the same lower beds of the Corniferous are worked, and this is the only quarry which is operated to any extent on the Toledo, Wabash, and Western railroad between Toledo and Wabash. Some of the material is shipped to Toledo, as there is a demand for it in the winter, when, on account of the ice, the stone quarried near Sandusky cannot be shipped to Toledo by water.

Near Defiance there is some stone quarried from the beds on the Miami river, and the same is true at Antwerp. The quarry at White House was not extensively worked until 1879, when the railroad track was laid into it. The cap-rock has been used for ballast on the railroad, so that the stripping is accomplished without expense.

The weathered rock which is used for ballast is from 2 to 8 feet in depth, and this is underlaid by 6 feet of gray-stone in courses of from 6 to 10 inches in thickness, 6 feet of blue-stone in courses from 6 to 18 inches in thickness, and one course of gray-stone 1 foot 10 inches in thickness. The bottom course is nearly uniform in thickness and is used for heavy bridge work. The blue-stone is not of a decided blue color, like that of the Upper Corniferous at Sandusky, but is a kind of grayish-blue.

Napoleon and Defiance, Ohio, and Fort Wayne, Indiana, furnish the principal markets for this stone.

In the townships along the Muskingum the sandstone, which is situated below the coal, affords an excellent building stone and is extensively quarried. The Waverly sandstone also occurs in the western portion of the county. The limestones which also occur in the county are, upon the whole, of rather inferior quality for purposes of construction, and would scarcely be worked if the lime which can be made from them was not of good quality and demanded for construction in the neighborhood.

SUB-CARBONIFEROUS.—A quarry situated at Newtonville, about 8 miles west from Zanesville, is the only one in Ohio from which limestones of sub-Carboniferous age are raised for building purposes. There are several large quarries in other exposures of this same horizon in southern Ohio that are worked exclusively for furnace flux and for lime-burning. The Newtonville stone is a beautiful material, very fine grained, quite even in color, and of great strength. It is very compact, highly fossiliferous, of light gray color, and has thus far shown no ill effects from exposure to the weather. The Muskingum County court-house, at Zanesville, one of the finest in the state, is built from this stone, and it has also been much used for caps, sills, columns, etc., and although the production at present is small, it may at any time be increased with a demand for the material; but at the present time most of the product is burned. A thickness of about 10 feet of stone is quarried, that being the depth to which natural drainage extends. Several feet more of the best of the stone lie below this level, and the thickness of the layers increases with the depth: upon the top there are only very thin beds, while at a depth of 10 feet the beds are 16 or 18 inches in thickness. The material is nearly a pure carbonate of lime, containing only traces of iron and magnesia. In its microscopic structure it appears to be quite highly fossiliferous and very compact, containing only small traces of iron pyrites, the oxidation of which imparts the faint yellow color which the stone generally possesses.

CARBONIFEROUS.—A quarter of a mile southwest of Zanesville, near the Muskingum river, a quarry has been opened in the limestone of the Lower Coal Measures, from which some material has been extracted which has been used chiefly for caps, sills, and top courses of foundations. The main product of this quarry is burned into lime. It is not used for the ruder purposes of construction, as it is too expensive. The ledge from which this stone is taken is a solid mass of a bluish color, and about 3 feet in thickness. The stripping which overlies the 3 feet of stone is 25 feet thick. The material is a compact, earthy limestone of a very dark color, containing considerable protoxide of iron and very little magnesia. It is very highly fossiliferous and difficult to work, and is called by the stone-cutters hard and plucky.

The outcrops of this stone are found abundantly in the neighborhood of Zanesville, and the material is quite extensively used for macadamizing streets. The national road for some distance west of Zanesville is constructed of it.

There is quite a large number of quarries situated in the outcrops of Carboniferous limestone in southeastern Ohio, the products from which are used as fluxes and for burning, but the two quarries which have been mentioned in Muskingum county are the only ones which are of any consequence as producing materials of construction. The Carboniferous limestones of this area are hard to work and do not possess the highest requisites of a good building stone, but these quarries are capable at any time of producing material for building, and in fact does so under special circumstances. Although these quarries are worthy of consideration in connection with their ability to produce building stones, still the industry is so insignificant that it has not been considered important to tabulate the products of any of them.

To recapitulate: The line drawn nearly through the center of the state from Erie county on the north through Adams county on the south will form the boundary between the area to the east, in which the chief quarrying industry is devoted to the extraction of sandstones, and the western area, in which the only quarrying industry is devoted to the extraction of limestones.

The geological formations in the limestone area follow one another in a quite regular order, the oldest being situated in the southwestern corner, and the youngest in the eastern part of the state: and the character of the stone is entirely dependent upon this geological arrangement, as regards both the character and the quality of the material.

A considerable quantity of stone is extracted from the Cincinnati group, but, as already indicated, this is chiefly owing to the circumstance that the material is in the neighborhood of the large city of Cincinnati. In quality the material is surpassed by the stone from other formations. A narrow band of Clinton limestone surrounds the area of the Cincinnati group, but at the present time this formation furnishes no building stones.

The Niagara or Cliff formation, which succeeds, is one of the great building-stone formations of the state, and in numerous places most excellent and durable materials are obtained; but even the subdivisions of this group determine largely the character of the stones extracted. The lowest or the Dayton formation produces at all points a hard, compact, light stone, while the Springfield division produces a less compact, more easily worked stone, and the top beds are almost universally converted into quicklime.

The Helderberg or Water-lime rocks, which cover a large area, are almost without exception bituminous dolomites, but in character vary from dark to light and from compact to open or vesicular. The Corniferous limestones are most extensively quarried in and about Sandusky, and furnish one of the finest materials obtained in the state, while all of the overlying formations are almost devoid of building-stone quarries. As regards composition, the stones from these various formations vary from almost typical limestones to almost typical dolomites, and there seem to be no rules which will enable one to decide upon the quality or durability of the stone from its composition. Experience also demonstrates that the composition, as regards the proportion of

lime and magnesia, does not determine the value of the stone as material for the production of quicklime. It would therefore appear that the value of the stone is more largely dependent upon its accessory constituents and its microscopic structure.

There is a progressive increase in the amount of magnesia from the Lower Silurian limestones to the Corniferous The Cincinnati limestones of the Lower Silurian contain from 1 to 5 per cent. of magnesian carbonate, while the Clinton limestones of the Upper Silurian contain on an average about 12 per cent. The Dayton limestone of the Niagara period contains about the same amount, while the upper divisions of the Niagara and the Helderberg formations are made up mainly of nearly typical dolomites. As regards composition the next following Corniferous limestones are very variable. At Bellefontaine the stone is a dolomite, and at Columbus it is as good a limestone, containing on an average 93 to 95 per cent. of carbonate of lime, and the Hocking Valley furnaces are largely using it for a flux.

In structure there is less diversity in the Ohio limestone than in those of some of the other states, since the oolitic and concretionary forms do not appear; but all other types are found, and therefore the greatest diversity exists in the case with which stones may be worked. There are the open, porous varieties, and the varieties which once were open and porous, but which have been again partially consolidated by the filling of the pores; others in which the pores have been entirely filled; and other varieties in which large crystals have developed themselves in a ground mass, giving to the stone a porphyritic aspect. There are the compact fossiliferous stones and the compact non-fossiliferous stones. As regards colors, they vary from very light to very dark, but all possess the drab, gray, or yellowish tints which are characteristic of what are called limestones.

In microscopic structure the limestones of Ohio can all be classified according to certain types of structure which are found to be correlated with composition. It may be at first remarked that the microscope indicates that the stones are all highly crystalline. A crystal is a body which possesses a definite internal molecular structure, and if it is further assumed that the external crystalline form is a property of crystals, then many Ohio limestones are more crystalline in their structure than are the so-called highly-crystalline marbles; for in a great many cases the very well developed crystals with external planes are developed in the mass of the stone, and in other cases the stone is entirely composed of such crystals with the form characteristic of the species of the mineral which composes it. In no case has there been found in any Ohio limestone anything which could be called in any correct sense of the word uncrystalline; and, indeed, in the light of the microscopic study, any distinction which can uniformly distinguish a limestone from a dolomite is very difficult to find. The progressive increase in the amount of magnesia which is contained in stones is indicated in the microscopic structure by the development of little rhombohedral crystals the sections of which appear quite conspicuous with their sharply-defined edges.

INDIANA.

[Compiled mainly from notes of Professor Orton.]

The rocks of the Cincinnati epoch of the Lower Silurian period occupy a small area in the southeastern part of the state, but no quarry rock is developed in this formation. Its western limit is roughly defined by a line drawn from Winchester, Randolph county, to Madison, Jefferson county.

The rocks of the Niagara epoch of the Upper Silurian period occupy a more extensive territory north and west of this line. This formation furnishes stone for foundations, underpinnings, and bridge work in nearly every county which it occupies. In a few localities the stone is suitable for the better architectural purposes, and in some places an excellent flag-stone is produced. The Helderberg formation has not been identified in Indiana. The approximate northern and western limits of the Upper Silurian formation are marked by a line drawn from Fort Wayne to Logansport, and thence to the eastern extremity of Clark county.

The Devonian formation occupies a narrow belt to the west of the Silurian. It has a meager development, its entire thickness being only about 200 feet, and it furnishes little building stone. The line between this and the sub-Carboniferous formation may be roughly drawn from the northwest corner of Benton county to the northwest corner of Clinton county, and thence to the southern extremity of Clark county.

As to production of stone, the sub-Carboniferous is the most important formation in the state. It furnishes the famous "Bedford limestone," and also some valuable sandstones, which are, however, mostly noted for their adaptability to the manufacture of grindstones and whetstones.

The Coal Measures occupy the southwestern part of the state, and the dividing line between this and the sub-Carboniferous formation is nearly that from the southern extremity of Perry county to a point about 5 miles southwest of the northeast corner of Warren county, and from there west to the state line.

The coarse sandstone, commonly known as the "conglomerate", at the base of this formation is found in a region on all sides of which for many miles little sandstone suitable for heavy masonry is available, and also near large districts entirely destitute of building stones; but as yet no large quarry industries have been developed in this formation.

The northern portion of the state beyond the line drawn across it through Fort Wayne and Monticello is deeply covered with drift material. The granitic bowlders found quite abundantly on the surface in some localities

furnish the only local supplies of stone in this extensive district. It is in this region that a considerable market is found for the sandstones quarried at Stony Point, Michigan, and Berea and Amherst, Ohio, and for the limestone quarried in the Bedford district in southern Indiana, and in the Joliet district of Illinois.

LIMESTONE.

The localities north of Indianapolis where limestone is quarried for building stone, with a few exceptions, deserve but a passing notice. At Wabash quite an important flagging stone is obtained at the quarries of Messrs. Bridges & Scot, Hubbard & Smith, Philip Hipskin, and William J. Ford; important because it is the best stone for sidewalk pavements to be obtained for many miles around. It occurs in layers from 1 inch to 7 inches in thickness, those from 2 to 5 inches thick being most commonly used for flagging, and the heavier courses for foundations and bridge work. The joints run quite regularly, and occur far enough apart to allow the largest required slabs to be obtained. The surface of the natural slabs is, however, rather too rough to allow the stone to be classed with the best of flag-stones. The quarry of Messrs. Moellering & Paul is in a different stratum of the Niagara limestone; the beds vary in thickness from 3 to 15 inches, and the stone is shipped to Fort Wayne, where it is used for foundations and underpinnings. The quarry of Messrs. Little & Shoemaker is in a thin, irregularly-bedded limestone, commonly called "shell rock". It is easily worked, and is cut through by the Wabash and Pacific railroad, which furnishes direct transportation for the quarry product to Fort Wayne, where such stone is in demand for ordinary foundations.

The quarries in Adams, Wells, Howard, Grant, Blackford, and Delaware counties furnish stone for light bridge work and for foundations.

The most valuable deposits of limestone that have been quarried for building purposes in northern Indiana are in Cass and Madison counties.

The quarries of Messrs. J. E. Burns and August Gleitz are located about 3 miles west of Logansport, Cass county, in the south bank of the Wabash river, and in a stratum of compact, though easily-worked, uniformly-colored limestone, in layers from 4 inches to 4 feet thick. These quarries have furnished the stone for the superstructures of some fine church buildings and for quite a large number of dwellings, stores, shops, etc., in Logansport. This stone presents a very pleasant appearance in a building when dressed rock-face. The stone from the quarry of Messrs. Lux & Lux, at Logansport, is used for foundations.

The Anderson, Madison county, quarries are located in an evenly-bedded limestone which works quite well under the chisel. This stone lies in beds from 4 to 12 inches in thickness, and is used in the town of Anderson for flagging, foundations, caps, sills, etc. It is rather beautiful and quite durable.

There is a number of localities in northern Indiana, south of the drift-covered region, where limestone is quarried for the manufacture of quicklime. A large amount of lime of excellent quality is burned annually at Huntington, and considerable amounts are burned at Peru and Delphi.

In the Upper Silurian or Niagara formation there are quarries of considerable importance in the southern part of the state, but by far the most valuable building stone of the state is obtained from a stratum of limestone in the sub Carboniferous formation. This limestone is supposed to belong in the geological scale to the Saint Louis group of the sub Carboniferous period. It occurs in massive beds of almost pure limestone, varying in different localities from an ordinary gray to an almost pure white color, and having a granular or oolitic structure. It is known by Indiana geologists as the "oolitic limestone", and is commonly known in the trade as Bedford stone and Indiana stone. A piece of the stone dressed in the shape of a flat bar rings like iron when struck, and it is very elastic, strong, and durable. It does not take a fine polish, but its adaptability to carved work is well shown in the elaborate carving in the mansion of Mr. William K. Vanderbilt, built of this material, on Fifth avenue, New York city.

In the Greencastle quarries the stone has a light gray or drab color, and is susceptible of receiving quite a high polish. This stone differs considerably from the sub-Carboniferous limestone in the Ellettsville, Stinesville, Bedford, and Salem quarries; it is harder, less granular, takes a higher polish, and occurs in thinner beds. This stone is used for the construction of cellar walls, for bridge work, blast-furnace flux, and lime-burning.

The quarries at Okalla, Putnam county, furnish material for bridge construction and for lime. The stone differs little from that quarried at Greencastle. At the Putnamville quarry the stone is heavily bedded, highly siliceous, quite hard, of a light gray color, and receives but a slight polish. It has a very compact, fine, granular structure. This stone is employed in all kinds of building, principally in the cities of La Fayette, Terre Haute, and Crawfordsville.

The quarries at Longwood, Fayette county, furnish stone for bridge work, cellar walls, steps, and some flagging. The material finds its principal markets at Connersville and Rushville. The specimens forwarded to the National Museum represent a buff variety and a drab mottled with buff. Both varieties take a medium polish, and from the latter tombstones have been made. The quarries near Laurel, in Fayette and Franklin counties, furnish stone for foundations, bridge work, and flagging to the country along the line of railroad from Cincinnati, Ohio, to Muncie, Indiana. This stone has quite a beautiful drab color, a compact structure, and is strong and durable. It works well under the chisel and takes a medium polish.

The New Point, Greensburg, and Saint Paul quarries, in Decatur and Shelby counties, furnish stone for general purposes of construction and for flagging. The material finds its principal markets at Cincinnati, Ohio, and at Indianapolis, Terre Haute, and La Fayette, Indiana. A section at New Point quarry exhibits 24 feet of drift; 3 feet of thinly-bedded rock, used for rubble and lime; and below this 4 feet of cutting stone. It is estimated that the value of the lime sold annually from this quarry is about one-third of that of its entire product.

The specimen forwarded to represent the material from this quarry contains numerous crystals of pyrites, varying in size from the smallest that can be seen with the naked eye up to half an inch in diameter. The stone works well, but does not take a good polish.

At the Greensburg quarry the stone is more crystalline and is susceptible of being quite highly polished. It is rather hard and slightly plucky. It is used for all building purposes, and the thinly bedded stone in the upper portion of the quarry is used to some extent for flagging and for railroad ballast. A section of the quarry exhibits 6 feet of drift material, 7 feet of thinly-bedded stone, and 9 feet of cutting stone.

At the Saint Paul quarries the stone is quite highly crystalline, works well, and takes a medium polish. It is used for all building purposes and for flagging. Mr. J. L. Scanlan manufactures lime, and it is estimated that the value of lime burned is about two-thirds that of the entire product of his quarry. The material which is burned is the thinly-bedded rock occuring above the cutting stone. A section of the quarry shows 4 feet of drift, 10 feet of lime-rock, and 10 feet of cutting stone.

A section of Mr. W. W. Lowe's quarry shows 1 foot of drift, 5 feet of thin stone, and 20 feet of cutting stone.

The quarry of Mr. G. W. McNeely, 2 miles west of Saint Paul and in Shelby county, is worked in 6 feet of thinly-bedded stone, and furnishes foundation stone and flagging to the neighborhood. The stone from these quarries may be equal in beauty and durability and even superior in strength to the oolitic limestone, but it is not so extensively employed, especially for the better kinds of architectural uses, because it is harder to quarry and to dress, and cannot be obtained so readily in large-sized blocks. It has been chiefly used for foundations and bridge abutments, and the thin, evenly-bedded layers are extensively used for sidewalk paving.

The oolitic limestone is quite extensively quarried in Monroe county, and the Ellettsville stone is used for all building purposes in Chicago, Saint Louis, Indianapolis, and also in many of the smaller cities and towns in Indiana and Illinois. The following are some of the buildings in which examples of Ellettsville stone may be seen: Indiana state-house, Marion County court-house, and the Vance block, at Indianapolis; the custom-house and post-office, Evansville; Knox County court-house, Vincennes; Dearborn County court-house, Lawrenceburg; Posey County court-house, Mount Vernon; Clark County court house, Jeffersonville; Bartholomew County court-house, Columbus; Johnson County court-house, Franklin; Asbury university, Greencastle; Wabash college, Crawfordsville—all in Indiana; and the state capitol, Springfield, Illinois.

A section of the quarry of Messrs. John Mathews & Sons shows first 3 feet of clay, then 7 feet of worthless rock, called "bastard" limestone, and, below this, 18 feet of limestone in one bed, which has, however, several "cone-in-cone" seams. This stratum has not been worked to the bottom in this quarry.

There are 2 feet of clay and 6 feet of bastard limestone over the building stone in the quarry of Messrs. Perry Brothers. The bed of building stone has been worked to a depth of 34 feet, divided into five layers by cone-in-cone seams. The stone in the top and bottom layers, respectively 8 and 6 feet thick, is quite hard, and is used in the construction of bridges. The intervening 20 feet consist of two layers, each 5 feet thick, and one layer at the bottom 10 feet thick. All the stone in these three layers is easily worked.

The disintegration of the fossil fragments, mostly coral, of which this stone is largely made up, has gone to such an extent in the Ellettsville stone that the fragments are very small, and the interstices between them have been so completely filled as to give the stone quite a compact structure. The representative specimen from the Stinesville quarries shows a much coarser and a more open structure, the fossil fragments being much larger and the interstices between them being less perfectly filled; however, the material is about as widely distributed, though somewhat less extensively, and is used for similar purposes.

The last mentioned quarries are located near each other. The one at the lowest level has 28 feet of limestone exposed, with a small honey-comb seam about 6 feet from the top. The two other quarries have about 30 feet of limestone exposed, with the honey-comb seam coming in at a depth of about 12 feet.

The entire section of the Saint Louis group is exposed at the quarry of Mr. B. Schweitzer, in Owen county, but the oolitic limestone is not well developed here. About 70 feet of limestone, varying, at different heights, in color, texture, and composition, are worked; and from 4 to 10 feet of the lower portion of this is a white limestone, which is burned. The lime product represents about one-fourth of the entire quarry product in value.

The building stone occurs in layers from 2 to 14 inches in thickness, being mostly a very fine grained and compact material, with a conchoidal fracture. It is not suitable for cutting; but, being evenly bedded, is well adapted for the construction of foundations, for which the blocks are easily squared up. The stone finds its principal markets at Indianapolis, Terre Haute, Vincennes, and Evansville, Indiana.

Bedford, Lawrence county, furnishes the "Indiana limestone", famous over a large portion of our country, known as "Bedford stone" in some markets. As is shown in the tables, most of the Bedford quarries now worked have been quite recently opened. The stone has only within a few years come into extensive use, though it has been quarried and used in a small way for twenty-five or more years. At the present time it is one of the stones most extensively employed for architectural purposes in the city of Chicago. The fossil fragments of which the stone is composed are quite uniform in size, of about that of an ordinary grain of sand, and the interstices between them are well filled, giving a uniform texture and firm structure. The appearance of the stone, when dressed in any manner applicable to limestones, is good. The qualities of beauty, strength, durability, and cheapness due to accessibility and ease of working possessed by the Bedford stone, tend to secure for it a very prominent place among the building stones of our country. The following are some of the buildings in which Bedford stone was used: Residences of Mr. W. H. Vanderbilt, Mr. I. Sherwood, and Mr. Cornelius J. Vanderbilt, Fifth avenue; residence of Mr. William H. De Forest, Fifty-seventh street; the Smith building, Cortland street; Appleby flats, corner Seventh avenue and Fifty-eighth street; Bridge building, Fourteenth street; flats, Eighty-fourth street and Eleventh avenue; and rectory, Fifty-first street—all in New York city; Cotton Exchange building, New Orleans, Louisiana; new city hall, Chicago; state capitol, Springfield; McLean County court-house, Bloomington; Peoria County court-house, Peoria; and county court-house, Olney—all in Illinois; new state-house and United States custom-house, Indianapolis; Grant County court-house, Marion; Lawrence County court-house, Bedford; county court-house, Shoals; Floyd County court-house, New Albany; Music hall, New Albany; Posey County court-house, Mount Vernon; United States custom-house and approaches, Evansville—all in Indiana; and United States custom-house and Jefferson County court-house, Louisville, Kentucky. In Louisville, Chicago, Saint Louis, Evansville, and Indianapolis there are scores of buildings the fronts of which are built of Bedford stone.

At some of the quarries there are from 4 to 5 feet of worthless rock on top; below this the solid bed of oolitic limestone has been worked to a depth of 40 feet, and the bottom of the bed is not yet reached. The amount of stripping varies in different localities. In some places there are but a few feet of clay on top of the oolitic limestone, while in other places the stripping consists of 12 or more feet of bastard limestone.

At the Lawrenceburg quarry, in the southeastern part of Lawrence county, and at the Fort Ritner quarry, near the line between Lawrence and Jackson counties, the oolitic limestone has not been so extensively quarried as at the Bedford quarries; the material, however, is of good quality. At Lawrenceburg the oolitic limestone has been worked to a depth of but 14 feet. From this quarry the material goes principally to Cincinnati and to Saint Louis.

At Fort Ritner only 10 feet of the limestone have been worked. The material was used in the construction of the court-house at Brownstown and the cathedral at Vincennes, Indiana.

The quarries in Jennings county are in the Niagara limestone of the Upper Silurian period, and the stone produced is quite like that from the same formation in Decatur county, which has already been described. Sections in these quarries show from 3 to 5 feet of drift material, and below this from 8 to 30 feet of quarry stone in evenly-bedded layers from 2 to 36 inches in thickness. The thinly-bedded layers are used quite extensively at Indianapolis and other cities for paving sidewalks. With these stones, when used for sidewalk paving and in rough masonry, nothing is necessary in the way of dressing beyond breaking the blocks into rectangular shape. The heavier layers are used extensively for the construction of foundations and bridge abutments, for which purpose this stone is well adapted on account of its strength, durability, and cheapness, due to the fact that little dressing is necessary for this kind of work on account of the evenness of the layers and the smoothness of the bed surfaces.

The specimen from the North Vernon quarries has a dark drab color, and that from the Oakdale quarry a light drab or gray color. The former represents what is locally known as the North Vernon "blue limestone", which was used in the construction of the Ohio River bridge of the Cincinnati Southern railroad. The strata occur near the surface of quite an extensive area along the lines of the Ohio and Mississippi railroad and its Louisville branch and the Jeffersonville, Madison, and Indianapolis railroad.

The quarries worked at Osgood, Ripley county, are also in the Niagara limestone, and the principal use made of the product is for flagging and curb stones. The material finds its principal markets at Cincinnati, and at Covington, Kentucky. At these quarries there are from 2½ to 5 feet of drift on top, and below this from 10 to 12 feet of quarry rock. The representative specimens of these stones forwarded to the National Museum contain a considerable amount of pyrites in the crystalline form. The stone is less applicable for cut work than for sidewalk paving, curb stones, foundations, etc.

Near Salem, in Washington county, the oolitic limestone has quite a valuable development. Under about 5 feet of cap-rock a solid stratum of limestone 30 feet in thickness occurs. Six feet of the lower portion of this, however, is not used on account of its being too hard. The remainder of the stratum is quarried for all kinds of building purposes, and the material finds its principal markets at Louisville, Kentucky, and New Albany, Indiana.

Samples of this material may be seen in the court-house at New Albany, and in the Galt house and city hall at Louisville, Kentucky. In color, texture, and ease of working this stone differs little from that quarried at Bedford.

At the New Albany quarries, in Floyd county, the oolitic limestone is somewhat harder and less valuable for architectural purposes. It is principally used for foundations and street pavements at New Albany. Only 9 feet of limestone is quarried, and the cap-rock is about 25 feet in depth—16 feet of clay and 9 feet of worthless sand-rock. This depth of cap-rock of course increases the expense of quarrying to a considerable degree, but the quarries can be worked with profit so far as the material may be in demand at the New Albany market for the above-specified purposes, no other material so suitable for the same uses being so near at hand.

ILLINOIS.

By Professor Allan D. Conover, *Special Agent.*

The state of Illinois embraces rocks representing most of the epochs of the Silurian, Devonian, and Carboniferous ages, and including most of their varieties in texture. Over the greater part of its area these rocks have been but little disturbed, and occur with beds approximately horizontal or inclined at a small angle to the horizon. In a few localities, however, very considerable disturbances of the normal relation of the strata have taken place, usually within rather restricted areas, and have been accompanied in some places by marked changes in the physical characteristics of the rocks, which have affected very considerably their value as building material.

The surface of the state is almost everywhere covered by a variable depth (at places but a few feet, at others much over 100 and possibly over 200 feet) of the looser deposits of the Tertiary and the Quaternary ages. Owing perhaps partly to the nature of its rock formation, but most largely in all probability to these subsequent deposits, a very large portion of the state presents a very level or slightly-undulating prairie surface, within the limits of which are but few rock exposures. This is true of the whole central and eastern part of the state, the larger portion of its territory.

Skirting this great area on all sides except the east is a country of very different character, though the change is gradual—a valley country with very marked water-courses, which cut through the beds of clay and sand to and into the rock formations below. Throughout the greater part of this area the rocks immediately underlying are Silurian, Devonian, or sub-Carboniferous, all of which furnish excellent building materials, and but few localities of considerable area are found where at least a fair building material cannot be easily obtained.

SILURIAN.

Lower Magnesian.—The oldest of the Silurian rocks occuring in the state, the Lower Magnesian or Calciferous, is found in two small areas in the central northern part of the state, one lying principally in Ogle county and the other mostly in La Salle county. Its beds furnish a dolomitic limestone, utilized in the manufacture of cement, but is only fitted for the most ordinary of building purposes, and is nowhere systematically quarried.

Saint Peter sandstone.—The Saint Peter sandstone, occurring closely associated with the Lower Magnesian limestone in these localities, is a coarse-grained sandstone of various shades of dark-yellow or buff to reddish-brown, its grains not often sufficiently cemented to form a good building rock. In a few places in Lee county it is hard enough to quarry, and small quantities of it have been and are yet occasionally used. In La Salle county the lower 4 feet of the bed furnish an excellent and durable rough building material, which was formerly considerably used for heavy masonry, but is now very little quarried.

Trenton group.—In its northern area the Trenton group has two very distinctly marked subdivisions—the Trenton limestone and the Galena limestone.

The Trenton limestone in this southward extension from its southwestern Wisconsin area presents here very similar characteristics. It is nearly everywhere a rather thinly-bedded, close-textured, often semi-crystalline, hard, gray or light drab-colored rock, easily blocked into quite square and regular shapes, and furnishing a very excellent and durable, occasionally somewhat ornamental, building material.

It is found and quarried in small amounts in numerous places along the valley of Fever river, in Jo Daviess county, and there furnishes a good ordinary building stone only. In the eastern part of Stephenson county it is quarried in a few places to a slight extent, but is everywhere so deeply covered by clay and shales as to render quarrying it very expensive, while farther east, in Winnebago county, it occurs in numerous places, and furnishes a good ordinary building stone, easily quarried out and shaped. In this locality some of the dark blue and drab colored beds fade very rapidly upon exposure, finally reaching to a light buff color, as in the same beds in Wisconsin, near by.

In western Boone county these beds furnish the only building stone of value obtainable within the county, and are extensively quarried in the vicinity of Beaver creek, where they furnish more than usually heavy beds of a rather rough but durable stone well fitted for ordinary and heavy masonry.

In the vicinity of Mount Morris and of Polo, in Ogle county, these beds furnish an excellent and handsome building material which has been used quite largely in building at those places.

At Dixon the stone is thinly bedded, but has been largely quarried and used in the construction of the mills at that place.

To the south of these places throughout the remainder of this area, and also in the detached area closely adjoining it, the Trenton limestone beds are thin and irregular, and nowhere furnish building material of value. Wherever these beds occur quarries are so easily opened and worked that large numbers of them are found, each worked to a slight extent, but rarely furnishing regular employment at one spot for any considerable length of time to more than one or two men.

The upper subdivision of this group, the Galena limestone, occurs in these northern areas of the Trenton group in considerable thickness, in all between 200 and 300 feet. It everywhere presents very constant physical characteristics, and is a rather coarse and rough-textured stone, occurring in heavy, sometimes massive beds to over 5 feet in thickness; is rather hard to work, and hardens gradually upon exposure, forming a very excellent, durable material for all purposes except for fine ornamental work. Its color is a rather rich, warm buff tint, which deepens somewhat upon exposure, and when well worked it presents a very handsome appearance.

In Jo Daviess county there are numerous quarries, though none largely worked. Near Freeport, in Stephenson county, and within the city, are large quarries presenting solid walls of rock from 60 to 90 feet high, in which the upper beds are very thin, but those below are very massive. Large quantities of stone from these quarries have been used in this city, and numerous very handsome buildings and residences have been constructed of it. Near Rockford, in Winnebago county, it has also been quarried and very largely used in that city, particularly in the construction of residences. At Harlem and at Cherry Valley, in the same county, there are also large quarries, the stone from which is extensively used for heavy masonry, such as bridge work, for which it is found to be a most excellent material.

In Ogle county there are numerous outcrops, and the stone has been considerably used for heavy masonry, but there are no quarries largely developed. In Lee county the formation is finely exposed all along the Rock River valley, and has been quarried extensively at Big Springs and at Lee Centre, while at numerous points along the valley small quarries have been opened. At Dixon it has been considerably quarried, and was used with success for the piers of the large bridge erected there across Rock river. Where found in Whiteside county it presents the same characteristics, but is generally difficult to quarry because it is nearly everywhere deeply covered up.

The Trenton group is found within the state at four other points along the Mississippi river to the southward, but these subdivisions seem there to be less distinctly marked and have not been recognized and traced.

In Calhoun county the rocks of the Trenton group form the axis of an anticlinal running east and west, and are largely exposed on both the Mississippi River and the Illinois River sides of the county. On the Mississippi River side at about the middle of the county they form the base of the river bluffs, and rise southward till at Cap Au Gris, in Lincoln county, Missouri, they form the whole body of the bluff, exposing a total thickness of from 300 to 400 feet. At this point the lower beds of the series are quite heavily bedded, compact, hard, grayish dolomitic limestone of great endurance, nearly, if not quite, equal in value to the limestone of the famous Grafton quarries in the Niagara limestone on the river, just below. These beds could be readily quarried and the stone lowered directly into barges in the river. A vast quantity of this stone can be readily and cheaply obtained.

On the Illinois River side of the county these rocks have numerous exposures, and are quarried in various places to a limited extent.

In Jersey county, where this axis crosses the Illinois river, the upper beds of this group are elevated above the river 40 or 50 feet. The rock is thinly-bedded, with shaly partings, and probably of little value as a building materia

In Monroe county the Trenton limestones are again found forming the base of the river bluff at Salt Lick point. They occur here in very heavy beds as thick as 6 and 7 feet, and are coarse-grained, quite even-textured, and of light color. From these same beds upon the Missouri side were obtained the great blocks for the columns of the Saint Louis court-house.

Farther south, in Alexander county, these rocks appear for the last time in this state and cross the Mississippi river in such a way as to form the rapids known as the Grand Chain. They rise on the Illinois side to a height of 75 feet or more and occur in very heavy beds—a light gray, fine, even-textured stone, some of the layers of which receive a high polish and would make an excellent and handsome ornamental stone. The same beds have been largely quarried at Cape Girardeau, in Missouri, just opposite, and the stone is known as the Cape Girardeau marble.

While in each of the last-named localities these beds are capable of furnishing quite cheaply vast quantities of building material, they have never, so far as I could learn, been worked to any extent.

CINCINNATI GROUP.—The rocks of the Cincinnati group, which immediately overlie those of the Trenton, consist mainly of more or less hardened clays, their composition in places varied by the addition of a considerable percentage of carbonate of lime. They furnish nowhere except in one locality any reliable building material, but are quarried in some places where their exceptional hardness renders them usable, and where other building stone is very scarce. In Boone county, where there is but one quarry (in Galena limestone, at Beaver creek) of limestone, a quarry has been opened in these shales just southeast of Belvidere, from which most of the building material for ordinary purposes used in that city has been obtained. In some buildings these stones have been exposed for nearly thirty years without showing much signs of injury. Very good flag-stones are also obtained from this quarry.

In the vicinity of Sterling, in Whiteside county, there are two considerable quarries in this formation which are especially notable. The rock is here a very compact, hard stone, and one quarry has been worked to a depth of about 30 feet. The upper beds are quite thin and can be taken out in very large slabs, which make very excellent flag stones. The lower beds are of moderate thickness with a compact, argillaceous limestone, furnishing an excellent building material, and have been quite largely quarried. Samples of this stone were tested by the United States authorities at Rock Island, and showed a strength to resist crushing varying from 7,000 to 10,000 pounds per square inch; in specimens 2 inches square and 4 inches high, a strength nearly equal to that of similar specimens from the Joliet and Lemont quarries. That this quality of stone has a very limited extent, however, in these beds the small quarries and other exposures within a limit of 2 miles show very conclusively. In Hopkins township, east of Sterling, is another similar quarry, where almost, if not quite, as good stone has been quarried considerably. A much less thickness of the strata furnishing good building stone is exposed here. In these quarry stones the addition of a considerable percentage of the carbonates of lime and magnesia has made the shales impure magnesian limestones and given them locally strength, durability, and reliability. At all other points where they are quarried, however, though they may in places appear to yield durable stone, they are liable to furnish occasional stones which, upon exposure, will rapidly disintegrate, and they are extremely unlikely to furnish anywhere any stone which will have more than a small local value, or be the basis of any regular industry.

NIAGARA GROUP.—The limestones of the Niagara group show in no place a thickness of more than about 100 feet, but are the surface stone over a very large area in the extreme northeastern, northwestern, and western part of the state. Nearly everywhere when exposed they furnish at least a good ordinary building stone, while in very many localities the stone quarried from them is of unusual excellence and applicable to almost all of the uses for which stone is required for building purposes. Their principal area of occurrence, in point of territory covered, lies in the extreme northeastern part of the state, where they extend from the northern boundary along the lake shore, and as far south as the central part of Iroquois county, in a band whose varying width averages about 40 miles.

In Jo Daviess, Carroll, Whiteside, and Rock Island counties are two very irregular areas of considerable extent. Farther south, in Pike county, and in Calhoun and Jersey counties, are two small areas, the latter of considerable importance, while in Alexander county, at almost the extreme southern point of the state, they occur again in a narrow area extending two-thirds the length of the county from near its northern boundary along or closely adjoining the Mississippi river.

In the first-mentioned area they are almost everywhere quite deeply covered with deposits of bowlder drift and clays, except where rivers or streams of some considerable magnitude have cut through these coverings. This is especially true of the extreme northeastern counties, McHenry and Lake, where the covering is very deep, and where those exposures which do occur or have been made show the rock to be too flinty and thinly-bedded to be of any value. To the southward, especially as they approach the southwestern limit of the area, the main valleys of the Fox and Illinois rivers show numerous exposures of the rock, most of which are capable of furnishing an excellent building material. The most important of these are found extending along the Illinois river from 2 miles above Lemont to a few miles below Joliet in an almost continuous line. The exposures of value for building stone are almost entirely confined to the left or south side of the valley, except at and below Joliet.

At Lemont the stone quarries lie on both sides of the Illinois and Lake Michigan canal, which here skirts along the valley above the base of the hills on the left bank of the river, though principally on the southwest. The beds are quarried to their lower limits through a variable thickness of from 12 to 40 feet. The stone here is uniformly a very fine grained, homogeneous, light drab limestone, occurring in beds from 6 to 24 and some times 30 inches in thickness. The beds are divided vertically by seams occurring at somewhat irregular intervals of from 12 to 50 feet, and continue with quite smooth faces for long distances, and also by a second set running nearly at right angles with the first, but only continuous between main joints and occurring at very irregular intervals. This structure renders the rock very easily quarried and obtainable in blocks of almost any required lateral dimensions.

The stone is easily worked into required shapes and takes a fine, smooth finish, which can hardly be called a polish. At the works of the Singer & Talcott Company large quantities of the stone are planed by machines closely resembling those used in planing surfaces of iron. This forms a very rapid and cheap method of finishing flagging stones and preparing stones which are to receive a smooth finish for the polishing-bed. Very large quantities of flagging stone are gotten out by this company, which for the past few years has supplied nearly, if not quite, nine-tenths of the stone for that purpose put down in Chicago, as well as large quantities for other places. The finer and more homogeneous varieties can also be very readily shaped into any of the forms which lathes are capable of turning out, such as balustrade work, and a great deal of this sort of ornamental stone-work is made here. The stone can also be readily carved in bas-relief, but is not sufficiently tough for high relief work. Its color is a bluish-gray to nearly white, and that quarried in the immediate vicinity seems to contain less iron oxide than that quarried lower down, at and below Joliet, and does not tarnish so much.

Quarrying has hitherto been largely done under very light stripping, but most of the future developments of these quarries must necessarily be done under very heavy stripping of clay and medium-sized gravel. This is here all done by hand. The stone here is injured by exposure to the frost while containing its natural moisture. This is a cause of either a considerable annual expense in making earth protection, or annual loss in destruction of stone, except in a few of the quarries so fortunately situated that they can be flooded during the winter season.

The principal market for the stone quarried here is the city of Chicago, but large quantities of the stone are also shipped in every direction to points throughout northern Illinois and the adjoining states of Michigan, Indiana, Iowa, and Wisconsin. These quarries extend for nearly 4 miles below Lemont, where a gap occurs, to just below Lockport, from which point a line of closely-adjoining quarries extends to below Joliet. The finer varieties of this stone do not seem well fitted for heavy masonry in damp situations. Fine clay seams abound, which are invisible when the stone is first quarried, and when it is used under ordinary circumstances generally do not develop at all, but in such situations as expose the stone to heavy moving loads, or to alternate moisture and dryness accompanied by frost, they are soon developed and often render the stone worthless. Even the purest and best of the stone, especially in cities where much soft coal is burned, becomes somewhat tarnished to a light yellowish tint after long exposure, but does not become of a strong buff color.

The quarries of the Joliet group extend from about a mile below the village of Lockport to about the same distance below Joliet. The total thickness of Niagara strata exposed here is apparently much greater than at Lemont, and two fairly distinguishable varieties of the stone are quarried. That quarried at the lower beds, in the vicinity of the penitentiary, on the right bank of the river, and just below the city closely adjoining the river, is generally a rougher, more irregularly-textured stone, occurring in beds as much as 24 inches thick, and is now chiefly used for ordinary and heavy masonry, and very little for ornamental purposes. This stone, upon exposure, becomes tarnished to a very decided and sometimes a quite deep buff tint, which is not a handsome color for face or ornamental stone. It appears, however, to be especially well suited to the purposes mentioned above.

In the quarries back from the river, at higher levels, the stone is generally a fine-grained, much more homogeneous rock, much of it quite equal in this respect to the best of that quarried at Lemont, and it occurs near the bottom of the quarries, as now worked, in beds often from 3 to 4 feet in thickness, and is obtainable in large blocks. Most of it appears to weather-stain rather more than the Lemont stone, but to be otherwise exactly like it. It is very largely used as a building and an ornamental stone, and large quantities of it are shipped by rail to points throughout northern and central Illinois, and to every one of the adjoining states. The value of the stone quarried at these two localities is probably fully equal to that of all the other stone quarried in the state.

Along the Fox River valley, from Elgin to Aurora, there are occasional exposures of the Niagara limestone, some of which are considerably quarried. In all of them, however, there is a heavy covering of drift, which renders the quarrying quite expensive.

At Batavia there are extensive quarries. The drift covering necessary to be removed is from 20 to 40 feet deep, almost entirely sand and medium-sized gravel. There are three large quarries on each side of the river whose products are all entirely similar. The stone is rather rougher, coarser, and more irregular in texture than that at Joliet and Lemont, and is more compact and difficult to work. A few of the beds furnish stone fit for ornamental work in fairly large sizes. The expense of quarrying has been very greatly increased by the heavier stripping required.

At Aurora there is also a very large quarry of the same excellent and durable stone, the product of which is mainly used for rough foundation and heavy masonry.

There are also quarries of some value at Thornton, on the Illinois Central railroad, and at Blue Island, on the Chicago, Rock Island, and Pacific railroad. There is also within the city limits of Chicago a quarry in the limestone of this formation, which is there impregnated with organic matter that gives the stone a dark and dingy tint upon exposure, and soon imparts to it an appearance of great age. It was used in the construction of one of the principal church buildings in the city, but it was most largely quarried for lime and ordinary wall stone.

At Kankakee, Kankakee county, there are two large quarries. The stone quarried there is a compact, coarse, somewhat irregularly textured dolomitic limestone containing rather numerous small cavities and sand-pits, but it is a strong and durable building material, especially valuable for resisting and enduring under very unfavorable circumstances when exposed to dampness and frost, and has very considerable strength. It has been largely used as face-stone in building work, but contains numerous crystals of pyrites which decompose and stain the stone dark yellow in patches, badly marring its appearance. Large quantities of the stone are used in bridge work along the lines of railroad passing through this place.

In the area of Niagara limestone lying in the northwestern part of the state, in Whiteside and Jo Daviess counties, are numerous exposures, and the beds furnish everywhere a rough-textured, heavily bedded, durable stone, excellent for all kinds of ordinary heavy masonry, but they are nowhere extensively quarried. Farther south, in northern Rock Island county, these beds, when found, are softer and excellent for lime-burning, but furnish no first-rate building material.

In Pike county the Niagara rocks form the base of the Mississippi River bluffs for a considerable distance. They are here of somewhat rough-textured, compact, buff-colored limestone of great durability, a building material for ordinary and heavy masonry quite equal to the best Joliet or Grafton stone. The same stone is also found high up on the river bluffs in southern Calhoun county, and also all along the Illinois and Mississippi River fronts of Jersey county to just below Grafton, and everywhere presents precisely the same physical characteristics.

At Grafton the stone is very extensively quarried, principally for the Saint Louis market, but considerable quantities of it are also shipped to other river points, the river having been, to the present time, the only channel for transportation available. The stone quarried here is of very great strength and durability.

The rocks of this group also occur in the river bluffs of Union and Alexander counties, in the extreme southern part of the state. Like the Trenton beds which they overlie, they are there mottled, semi crystalline rocks, occurring in very heavy beds, the stone taking a fine polish and capable of yielding a very handsome ornamental stone, as well as a thoroughly reliable and handsome building material. They are not, as far as I could learn, yet worked.

DEVONIAN.

The Devonian age is represented in Illinois by a series of shales and limestone, of small total thickness, varying from 10 to over 100 feet. The exposures of these rocks are not numerous and are of very limited extent. In Calhoun county they include about 10 feet of a coarse, gray limestone, useful and slightly used as a building material. In Jackson, Union, and Alexander counties some of the beds might be utilized for the same purpose.

In Jackson county there are beds in the Devonian series at Bald Hill and at Back Bone which are very hard and even-textured and take a fine polish. They are of variegated color also, and have been worked to some extent. Other beds in the same series also furnish excellent rough building material.

CARBONIFEROUS.

The rocks of the Carboniferous age underlie the greater part of Illinois. They form a series of very great thickness in their greatest development, probably over 2,500 feet, and are of very great importance not only because of the mineral wealth, especially of coal, but also because of the vast, almost unlimited, quantities of most excellent building stone they are capable of supplying, and very cheaply, at great numbers of points over the state. This is especially and particularly true of the lower division of the group, the sub-Carboniferous limestone, so called, which furnishes a maximum thickness of limestones, sandstones, and shales: principally limestones of over 1,500 feet, in the southern part of the state, which gradually thins out to less than 1,000 feet total average, toward the northern limit of their exposure. A very large proportion of these beds furnish excellent building stones wherever found.

The most northerly exposures of these beds occur in southern Mercer county, and from here they extend southward in an area of very variable width from 5 to 30 miles or more, always along or close to the Mississippi river, and nearly the whole length of the state to southern Jackson county, where they swing to the eastward and cross the state, through Union, Johnson, and Pope counties to Hardin county, at whose easternmost limit they cross the Ohio river into Kentucky. They form the whole or the greater part of the Mississippi River bluffs throughout the entire distance from Mercer to Jackson county, with the exception of the limited localities already described, where the river front is occupied by older rocks. Five main subdivisions of the rocks of this group were made by the Illinois geologists and traced throughout most of the area.

KINDERHOOK GROUP.—The Kinderhook group, the lowest and least important of the series, has at its greatest development a thickness of less than 200 feet, which in places includes limestone strata of no great thickness available for building stone, but which are not always a reliable material, and nowhere extensively quarried.

BURLINGTON LIMESTONE.—The Burlington limestone, next in the series, occurs in beds whose variable thickness amounts in many places to over 200 feet; it is a very pure carbonate of lime, highly fossiliferous, and for almost its total thickness is an excellent building material.

In Henderson county it outcrops along the river bluffs through the whole length of the county. It is a fairly even textured light blue or yellowish-gray, moderately thick-bedded stone, but little affected by weather. The beds have been quite largely worked in the eastern part of the county, and also at Sagetown, where a very extensive quarry furnishes a large quantity of material, principally used in railroad constructions. The stone for the piers of the Mississippi River bridge at Burlington was taken from this quarry and has stood the exposure and abrasion with great success, and seems also to have been discolored little or none.

It forms no part of the surface of Hancock county, but in Adams county is again exposed along the whole line of river bluffs, from Quincy to the southern line of the county, having everywhere about 40 feet in thickness of moderately heavy beds of excellent but rather rough-textured building stone. At Quincy, within the city, a thickness of about 100 feet of this limestone is quarried, and is most of it available for building stone; an excellent and durable material, but not a fine ornamental stone. Some few of the layers contain pyrites and become badly discolored upon exposure.

Throughout the whole river front of Pike county, both on the west and on the east, these beds form a continuous outcrop, including, as in Adams county, about 40 feet in thickness of beds available as building material. The stone is here often found in beds from 2 to 4 feet thick, and is, wherever free from flints, an excellent building and dimension stone. Numerous exposures are also found along the creeks in the northern part of the county.

In the vicinity of Jersey landing, Jersey county, it forms the entire river bluff, and is a nearly white, somewhat mottled, medium-bedded limestone, containing occasional seams and flints, and furnishing a very good building stone for rubble and ordinary cut-stone masonry. It is very little quarried now.

KEOKUK GROUP.—The Keokuk group, next in succession, consists chiefly of limestones. Its rocks extend in Illinois from central Henderson county along nearly the whole band of sub-Carboniferous rocks to Hardin county. Only the middle beds of this formation furnish good building material, and in these there are a number of noteworthy quarries. Their extreme thickness is about 70 feet, and the rock is an even-textured, light gray colored,

easily dressed stone, which does not discolor or show any signs of disintegrating upon exposure. In most places its beds are separated by clay seams sometimes of several inches thickness, the beds themselves varying from 6 inches to 3 feet.

In eastern Henderson county these beds are exposed in numerous places, especially in the vicinity of Biggsville, and there furnish only an ordinary building stone in blocks of very moderate dimensions.

In Hancock county these beds form the base of the river bluffs for a long distance, and have been extensively quarried in a number of places. Near Nauvoo large quarries were at one time worked, and furnished the material of the once famous Mormon temple at that place. Stone from these quarries was used also in the construction of the United States court-house and post-office buildings at Galena and at Dubuque. South of here about 4 miles the Tallant Stone and Marble Company has opened a considerable quarry in the same beds, and furnishes a rather coarse, uniform textured, white, and very light gray limestone, which is easily cut, sawed, and shaped, and does not tarnish upon exposure. Some of the beds furnish stone which can be polished, and in places some of the beds contain much cherty material, while others are entirely free from it. Very large blocks are easily obtained. The same beds have also been much quarried at Hamilton and Niota in the same county.

The analysis of this stone (*Illinois Geological Report*, Vol. I, p. 99), specimen from Nauvoo quarry, gives:

	Per cent
Carbonate of lime	82.48
Alumina and iron	2.10
Insoluble matters	12.50
Water and loss	2.92
Total	100.00

Throughout Adams county where these beds are found they furnish, when free from flints, a stone precisely similar to that at Nauvoo. They outcrop in very many places throughout the northern and northeastern part of the county.

In Pike county the beds of this group, which rest directly upon the Burlington beds, furnish an excellent building material very like that of those beds. They outcrop, especially in the vicinity of Griggsville, where the beds are unusually free from flints. In Jersey county, though there are numerous exposures, they furnish no excellent building material on account of the number of flints they carry. In Hardin county a heavily-bedded limestone, in layers from 1 foot to 3 feet thick, outcrops along the Ohio River bluffs, but is not quarried for building material.

Saint Louis group.—The beds of the Saint Louis group furnish a very large amount of building stones of considerable variety in texture and properties. In Hancock county the lowest beds of the series are of a somewhat arenaceous magnesian limestone, generally of a light yellow or buff color, darkening upon exposure. The stone cuts readily and can be obtained in quite large blocks, and possesses very great durability in the most trying situations. Large quarries in these beds were opened and extensively worked just at the head of the Keokuk rapids, on the Illinois side, and furnished nearly all of the riprap for lining the government canal around those rapids, beside considerable of the cut stone used in the locks, where it has resisted very successfully. These quarries have been abandoned for several years, however. This stone readily breaks into blocks for the better class of rubble, very square and of convenient sizes.

Below Warsaw these beds attain a very great thickness, and are quarried considerably in a good many localities. They nearly everywhere contain minute crystals of pyrites, which decompose upon exposure and discolor the stone. There are also numerous exposures upon the creeks in the eastern part of the county. These same beds are also found in the northern and northwestern part of Adams county, where the rock is of the same character. In Pike county they are only found in the extreme northern and northeastern part, and where occurring furnish the same brown magnesian limestone, a most excellent and durable building material.

In Calhoun county they form a continuous exposure along the river bluffs, and are everywhere a rather thinly-bedded and hard but very durable building rock, and would furnish an almost inexhaustible supply.

In Jersey county the principal exposures occur along the Piasa; and on the Mississippi river, just south of the Piasa, at its mouth, in Madison county, are also large exposures. The beds here are nearly true dolomites, are often found with very heavy layers, and furnish a very excellent heavy wall stone. Some of the upper beds at this last locality take a fine polish, and could be used as an ornamental stone; they also furnish excellent flags.

The bluffs at Alton present a thickness of over a hundred feet of these beds, the whole of which is quarried for lime and building stone. The middle and lower beds furnish some excellent hard, even, close textured rock, in every respect good building material. The brecciated beds found here have been largely used for rough, heavy masonry, but observation shows them unreliable for that purpose, gradually becoming separated into irregular fragments.

In Saint Clair county a total thickness of about 200 feet of these beds is exposed, nearly all of good building material and available. Some of the thinner beds furnish an excellent flagging, while the heavier beds contain a light gray, compact stone, excellent for every variety of mason work. They form the river bluffs through most of the southern part of the county. In Madison county the beds exposed are also dolomitic to some extent; at places pure

dolomites (specimens analyzed at the Smithsonian Institution, Washington, proved to be calcareous dolomites). They furnish everywhere an excellent material for building purposes. Occasionally the stone is sufficiently hard and compact to take a fine polish.

In Monroe county the rocks of this formation are pretty well distributed over nearly the whole of the county. They are extensively quarried at Columbia and at Waterloo. In the vicinity of the latter place the rocks quarried are especially suitable for cut stone work of every variety. They are of a bluish-gray color, sometimes nearly white.

In the vicinity of Columbia there is exposed in the lower division of these beds about 20 feet in thickness of heavily-bedded, light gray, granular limestone entirely free from flints, splitting easily and furnishing blocks of any required size. There are also in the lower division of these beds heavily-bedded buff limestones which make most excellent heavy wall-stone. These are exposed in about 100 feet thickness at and in the vicinity of Salt Lick point, on the Mississippi river.

In Randolph county they also occur in the northwestern part of the county 200 feet thick and in beds similar to those in Monroe county.

In Jackson county these beds furnish some good building material.

In Union county, in the vicinity of Jonesboro', are numerous quarries, not now much worked, of massive, granular, nearly white limestone, an excellent building stone for ordinary situations: they are of fine appearance and obtainable in large blocks, but are said not to resist when exposed to frost in damp places.

In Johnson and Pope counties also these beds would furnish excellent building material in large quantities, but they are nowhere worked. At Roseclair, in Hardin county, large quarries were worked for many years in the beds of this formation, and are yet worked, though not on so large a scale.

Oolitic beds occur in the bluffs just below the village, and are somewhat quarried. They furnish a very hard, fine stone which takes a high polish, has a dark bluish-gray color, and is a very durable and handsome stone. Large blocks are readily obtainable. Places for several large quarries conveniently located on the river can readily be found here.

CHESTER GROUP.—The beds of the Chester group expose a thickness in places of over 600 feet of alternating limestones, sandstones, and shales, capable of furnishing large quantities of fine building material. One of the sandstone beds of this group is found capping the bluffs at Alton, where it is a clear, white, pure siliceous sandstone, fine-grained, perfectly homogeneous, and occurring in massive beds from which very large stones might be obtained. It shows no tendency to discolor upon exposure. It is little quarried, and not at all for ornamental purposes, for which it appears very suitable.

In Saint Clair county the lower sandstone of the group furnishes a durable stone, buff or brown in color, easily quarried and cut, hardening upon exposure, and obtainable in blocks of any required size possible to be handled. Overlying this is a thinly-bedded limestone of the same group available for common wall masonry.

In Monroe county the lowest sandstone of the group shows in a thickness of 60 or 75 feet, generally evenly-bedded and uniform-textured, but occasionally concretionary. This outcrops in numerous places in the southeastern part of the county. Some of the limestones of the group outcrop here also, and furnish good rough building stone.

In Randolph county, where this series finds its greatest development, the lower limestone of the series is 150 feet thick. It is all fit for ordinary building stone, while some of the beds also furnish excellent dimension stone for cut work. Some of the upper limestone beds of the series also furnish excellent material for cut-stone work.

The Penitentiary quarry at Chester is worked in these beds, and much riprap, rough building material, great quantities of paving blocks, and considerable cut stone of fine appearance are obtained.

The lower sandstone of the group is here precisely similar in characteristics to the same beds in Monroe county, but is here more than 100 feet in thickness. It has been somewhat quarried just above Chester, where it can be made to furnish blocks of great size. It is a stone of great strength and durability, and presents a uniform and good appearance, its color, however, being somewhat against it.

The other sandstones of the Chester series furnish a fine-grained, soft, even-textured, buff and brownish colored stone which cuts with great ease when first quarried, but hardens upon exposure and changes color very slightly. It is a rather handsome building material. The southern Illinois penitentiary is built largely of these sandstones, and presents a fine appearance.

In Jackson county, where they occur, the limestones of this group are generally too siliceous and too hard to work, and usually furnish stone only for ordinary building purposes. The sandstones, however, can furnish large quantities of excellent building material. They are soft, fine-grained, harden on exposure, are durable, and usually of dark brown or strong yellow color.

In Union county, when not too argillaceous, the limestones furnish good building material. At Cobden there is a very heavily-bedded, compact, dark blue, very hard limestone, very difficult to cut, but which would make a most excellent bridge and culvert material, and has been somewhat used for that purpose.

In Johnson county the sandstones of this group occur in easily workable position in numerous places, and would furnish excellent flagging and dimension stone. Some good building material is also obtainable from the limestones.

In Pope county, while some few of the sandstone exposures furnish a fine building material, most of the outcrops show the stone to be too hard and uneven. Where exposed near the Ohio river the limestones of this group furnish excellent building stone for the finer classes of work.

In Hardin county some of the sandstones are very refractory and are used for furnace linings. They furnish also some good flagging and some fair building material.

The Coal Measures underlie the greater part of Illinois, probably three-fourths of its territory; the greater portion of the territory is deeply covered with the more recent clay deposits, and exposures are rather scarce. In the southern part of the area there is, however, a less depth of these deposits, and more numerous exposures, many of which furnish building material of some sort. These rocks comprise here, as elsewhere, alternate beds of sandstones, shales, limestones, and conglomerates. Most of the sandstones are coarse and irregular in texture, and generally disintegrate upon exposure. In the southern part of the state there are, however, many places where they are hard, fine, and tolerably durable, and in many localities furnish excellent flagging and good building material. The limestones of the series are generally rough-textured, thin-bedded, and shaly, and in but few places furnish a material fit for ordinary use. In comparison with the sub-Carboniferous beds, these, however, will furnish but a small total amount of really excellent material.

The points where beds in this formation have been worked are few in number and of little importance generally.

Between Cobden and Mahanda, on the line of the Illinois Central railroad, and adjoining the track, is a small quarry in a medium-bedded limestone, which might be very greatly enlarged. The beds are regular and even, and the stone appears to be quite durable.

Three miles south of Carbondale, on both sides of the little creek through whose valley the railroad runs, are exposures of a reddish sandstone of considerable value for building material. It is a medium-grained, even-textured stone, fresh fracture, dark red, weathering to a purplish-gray tint, easily quarried, but becoming quite hard upon exposure. At the top of the eastern bluff a large quarry was once worked but is now abandoned. The convenient outcrop could supply a great quantity of the material. The bed seems to be about 14 feet thick, and would easily furnish sawed stone 4 by 10 by 40 feet in one piece. The stone for the State Normal School building, a very handsome structure, was obtained at this quarry. On the west side, opposite, are excellent exposures of the same rock, forming a similar ledge low down on the bluff. The beds lying above this ledge are thin and hard, and furnish a fair flagging, which is quarried in moderate quantities at this place.

At Xenia, Clay county, there is a small thickness of drab-colored, fine-grained, even-textured sandstone exposed in a creek valley for 2 or 3 miles, furnishing a fair building and ornamental stone, and is quarried and shipped in moderate quantities. There are also said to be sandstone exposures along Crooked creek, in the same county, of considerable value for building purposes.

At Carlyle, Clinton county, are small quarries in a rough-textured, durable limestone; and on Shoal creek, a few miles west of Carlyle, limestone strata of fair quality for both ordinary and cut-stone work are found outcropping in a number of places, and are quarried in a small way.

In Greene county are beds of sandstone which would furnish considerable quantities of fair building stone, and there are numerous other exposures of like character. In no place, however, are there any beds which are likely to prove of more than local importance.

In the northern part of this area the covering of the rock formations is so deep and the country so level that large districts are without rock exposures, and depend entirely for their supply upon the means of transportation. The county, however, is crossed in every direction by railroads. While the resources of the state within herself are sufficient many times over, it is quite likely that much of the building stone for the state, especially in some portions of it, will be brought from Ohio and Indiana, because of its great excellence and proximity to the market.

Nearly all the northern, western, and southern counties have ordinary building stone in great abundance and well distributed.

Increased facilities for transportation have been rapidly extended throughout many of the counties richest in this particular commodity, which have hitherto had no railroads, and this must undoubtedly result in the development of considerable industries in quarrying and shipping of these materials to the less favored districts.

I have to acknowledge my great obligation to the Illinois geological reports for facts about much of the territory having no present quarrying industries, which could not be visited, and for other facts gleaned from that report and incorporated herein.

MICHIGAN.

By Professor Allan D. Conover, *Special Agent*.

The state of Michigan contains rocks representing a larger range of geological formations than those of any of the adjoining states, but within her limits their lithological character and mode of occurrence, as also those of the later and looser deposits, are such that there are comparatively few points where the quarrying of stone for building purposes is ever likely to become an important industry, but at some of these it is of very considerable importance.

The Archæan rocks occur only in the northern and northwestern parts of the northern peninsula, and have not as yet furnished any building stone. The Huronian subdivision, however, carries beds of very considerable thickness of slates of very great value as roofing material. These have unusual development in the vicinity of Huron bay, on the coast of lake Superior, and were during the last decade opened and worked at a number of points, all in the same vicinity, in township 51, range 31. Several stock companies were formed, with large capital, each owning large tracts of land in this township, and some work was done in developing quarries, but the difficulties of transportation and shipment and small market for their product led to their temporary abandonment and the failure of the companies owning them. These beds furnish slate very readily cleavable, generally of black color, but also occurring in places of green, purple, and gray colors, in vast quantities, and so far as their exposures and the limited trial given them go to show, of very considerable enduring power, and they bid fair to be of very considerable value as the development of this and the adjoining states creates more market for material of the kind. Besides these deposits I do not know that these rocks furnish any material now used in building, or any whose character, so far as known, renders them likely to be quarried for that purpose even to supply local demand.

Beds of limestone, altered to marble, occur associated with the granitic rocks of the Laurentian, which furnish very numerous handsome specimens, but do not, I believe, occur anywhere, as yet discovered, where large blocks of material of homogeneous character can be obtained in quantity. It is quite possible that the granitic beds may some time furnish valuable building material of that class, and also that the quartzites which occur in large quantities and are easily reached may also furnish valuable paving material where the location of outcrops of the suitable quality occurs conveniently to cheap transportation facilities; but as yet nothing of that sort has been developed.

The Potsdam sandstone is likely to furnish the largest quantity and the best of the building material found within the state. Its occurrence is mainly in the northern part of the Upper Peninsula, where very numerous exposures occur, especially along the lake shore. The lower beds of this formation furnish a rather coarse grained, homogeneous, siliceous sandstone, rather soft when first quarried, and easily hewn, but hardening on exposure. Its color is generally reddish, or some shade of reddish-brown, and, when uniform, renders it a very handsome material for outside and ornamental work. It often occurs of mottled-white or yellowish-white and red-brown colors. These parts of the stone are usually rejected, though some buildings have been built of them at Marquette and also in Chicago, and present a rather handsome, picturesque appearance. They seem to be equally durable with the rest. The stone usually occurs in approximately horizontal but usually very uneven beds, and is always readily obtainable in large masses. In most places where quarried the stone carries occasional, sometimes numerous, pockets of clay of very various sizes, which considerably affect its value by causing much waste and rendering the stone unreliable. Where free from these, however, the stone is a durable and reliable one, and always commands a high price and a considerable market in all the large lake cities.

It was, during 1880, only quarried regularly at one quarry, which is within the city of Marquette. Numerous attempts to quarry elsewhere have usually failed, principally from the difficulty of obtaining a safe harbor at the quarry spot. This difficulty is very likely, however, to be overcome, so that quarries will be opened in numerous places. These beds occur especially in the vicinity of Marquette, in many places along the lake shore, west of Keweenaw point, and also near the eastern end of the coast of lake Superior along the lower valley of the Laughing Whitefish river and the country around it. In this latter locality the stone is very hard, compact, reddish, or speckled, is heavily-bedded, readily splits to required thicknesses, and is especially suitable for heavy masonry, but, because of its hardness, not well suited for an ornamental building stone. It is found underlying a very large territory and is easily obtainable almost everywhere.

The Calciferous group occurs in the Upper Peninsula only where it extends in a very narrow band from a point some distance northwest of Menominee, northeastward, swinging to the east, to the extreme eastern end of the peninsula. It exposes an extreme thickness of about 100 feet of calcareous sand-rock of very variable character, the more calcareous beds of which sometimes furnish good building material in rather thin beds and blocks of moderate size. They are, however, nowhere regularly worked as yet, the country they underlie being still entirely a wilderness.

The Trenton group is represented on the Upper Peninsula by beds of perhaps 100 feet greatest thickness of thinly-bedded shaly limestones, which have nowhere been discovered of such character as to furnish a first-rate building material. At places it is thick enough and sufficiently even bedded to quarry out in good shape, is of compact or crystalline structure, but everywhere yet worked contains too many irregular argillaceous seams to render it a safe and reliable building material. It also extends in a narrow band from west to east, through nearly the whole extent of the peninsula, just south of and adjacent to the band of Calciferous rocks. It is crossed by all of the important streams flowing into lake Michigan, and, in most cases, forms upon them falls or rapids of considerable extent, so that exposures are very numerous. To the southward lie the Niagara beds, in a similar but wider band, which covers most of the southern part of the Upper Peninsula, extending from Big Bay de Noguette eastward to the limit of the state. They furnish usually a hard, compact limestone, often in very heavy beds, but generally containing so many seams of argillaceous material as to render them liable to split and crack under the

action of frost. Some of the beds are free from these seams. Most of the region where these beds occur is a wilderness, and the beds are, moreover, heavily covered with drift, except where the streams have cut their way through. A few quarries have been opened and worked to a limited extent.

The beds of the Hudson River shale, lying in a narrow band of country between the last-mentioned formation, are everywhere too soft and too easily affected by weather to be of value as a source of building material, and can never be expected to supply material fit even for ordinary purposes.

The Helderberg group furnishes limestones of considerable hardness in places, but everywhere occurring in a brecciated condition which renders them unfit for building material.

In the rocks of the Onondaga Salt group there are on the Upper Peninsula some beds of fair gypsum, and quarries were formerly worked in them near Point aux Chênes, but were long ago abandoned. This completes the list of the rock formations of the Upper Peninsula.

Passing southward through the Lower Peninsula, we cross successively the beds of the later formation to the basin filled by the Coal Measures, which cover a disk like area in the southern central part, around which the earlier formations occur in concentric rings.

The rocks of the Helderberg group occur on the Lower Peninsula at its northern extremity and upon the adjacent islands, and everywhere furnish impure limestones of some value for lime, but so brecciated as to be entirely unfit for any building purposes, except the lightest and most ordinary cellar masonry. They occupy also a small area in the southeastern course of the Lower Peninsula, and there furnish beds of some considerable value. At Trenton, near Detroit, in Monroe county, is a very extensive quarry in these beds. They furnish a somewhat impure limestone, occurring in beds from 1 inch to 12 inches thick, from which no large stone can be obtained owing to numerous dry seams which occur throughout the mass. The heavier beds only are utilized for building material, and are close, compact, and rather fine grained, sufficiently hard to take a fair polish, but fit only for ordinary rubble work, while blocks selected with the greatest of care furnish material fairly fitted for such ornamental work as caps, sills, etc. Very little of the material, however, is utilized for such purposes.

Upon Macon creek, in the valley, are a number of small quarries in the beds of this formation which expose a total thickness of about 8 feet of beds 6 inches to 2 feet in thickness, and a much more compact, gray, crystalline limestone of considerable strength, and very free from the dry seams found in the rock at Trenton. The beds in the valley are covered only by from 2 to 6 feet of loose earth and can be very easily quarried. They furnish excellent material for all ordinary mason work and for very good-appearing cut-stone work, though somewhat difficult to hew. Some of the upper beds in this locality are also brecciated.

A sandstone bed of small thickness also occurs among the beds of this age which in places contains a considerable proportion of calcareous cement, and is a firm, compact rock obtainable in fair-sized blocks, nearly pure white, and to all appearances a fair and quite handsome building material. This bed was seen at the surface on Fritz Rath's farm, near Raisinville. There are also in the limestones a number of small quarries along the valley of Raisin river and Plum creek which furnish good building material. The most important of these are at Monroe.

There are in the southern part of the Lower Peninsula no beds representing the Hamilton period, but in the northern part they occur in great thickness and form the surface rock over a very considerable area adjoining that of the Helderberg group, and extending across the whole width of the state. They consist of alternate beds of limestones and shales, some of the former furnishing fair building material, quarries in which are worked at Alpena and vicinity. The stone obtained is very hard, compact, and durable, but is obtainable only in moderate-sized blocks. It is well suited for all ordinary plain ornamental stone-work, but has a rather dull, light drab color, rendering it not very attractive for the latter. It appears every way a durable and reliable stone. It is not obtainable anywhere in large quantities, but in numerous places supplies the local demand for common building stone. Where it outcrops along the shore of lake Michigan it can be quarried in several places and loaded directly upon barges in the lake.

The black shales, next in order in the geological series, furnish no material for construction.

The Waverly group, next succeeding, is by far the most important of the series in the Lower Peninsula, and furnishes a large proportion of the good building material obtained. The rocks of the group consist of alternate sandstones and shales; the sandstones, which furnish the building material, vary considerably in texture and composition, but furnish in many localities valuable building stone.

Along the south shore of Saginaw bay from Point aux Barques southwest there are numerous exposures of the sandstones of this group. At the point itself a thickness of about 16 feet of these strata is exposed, which would furnish excellent building material.

At Grindstone City, just southeast, are other exposures which are extensively worked for grindstones, for which they furnish excellent material. Some of the stone has been used for building purposes, but it has more value for its present use.

There are numerous exposures elsewhere, especially in Jackson and Hillsdale counties, very few of which have been much worked of late years. The increase of railroad facilities has greatly increased the use of the superior Ohio stones. The most notable quarry in the formation is that at Stony point, in Jackson county, where a

thickness of about 40 feet of fine-grained, buff-colored sandstone, very soft and easily dressed, but hardening upon exposure and retaining its color well, is quarried under very heavy clay stripping, and blocks of any required dimensions are easily obtained.

Beds of the same formation are also exposed at and near Jonesville, Hillsdale, Osseo, Moscow, Homer, and Condit station, in the same region, and on Black river, near Holland, Ottawa county, farther northwest. There are, however, no very important quarries, and at only a few of these places can really good stone be obtained.

The Carboniferous limestone at the base of the Coal Measures has a comparatively small development in this state, and nowhere furnishes building material of much importance. There are quarries in these beds at and near Bellevue, Eaton county, and north of Jackson, at the junction of Grand and Portage rivers. At these places the beds furnish pure, light colored limestones in beds of moderate thickness, a very fair building material for ordinary uses. These beds also occur on some of the islands on the east side of Saginaw bay, and furnish an excellent building material for foundation walls.

The sandstones of the Coal Measures sometimes furnish very good building material. The most noteworthy quarry in these beds is that near Ionia, Ionia county, where a bed of dark red and mottled yellow or white and red stones occur in horizontal position in layers of moderate thickness, and furnish an easily-quarried, medium-grained, easily-cut, and hardening sandstone in blocks of considerable size, and a very handsome building material. The beds from the lower part of the quarry are of an even brown color; those near the top are mottled. This stone has been much used in the vicinity both for ornamental and heavy masonry purposes, and has proved itself well suited to all classes of building construction. A very handsome church edifice has also been built of the brownstone at Detroit. Beds of these sandstones are also found at Jackson, where they are somewhat quarried, and near Lansing, at Grand Ledge, and at Flushing, near Flint, but they are nowhere regularly worked, nor do they furnish any very desirable material.

The resources of the southern peninsula in building stone are comparatively very limited, except in such ordinary grades of the material as are necessary for house-foundation purposes, and even for that purpose stone is frequently lacking in very large districts. This is in part compensated for by the numerous railways which traverse the state, the close proximity of the numerous excellent building stones of Ohio, and the cheap lake transportation by which the resources of the Upper Peninsula can be reached.

WISCONSIN.

By Professor Allan D. Conover, *Special Agent.*

SILURIAN.

The great bed of Silurian rocks which almost completely encircles the Archæan area of northern central Wisconsin had previous to the census year furnished practically all of the building stone quarried within the state. Every one of the grand divisions of the belt furnishes in one or more localities material fit for ordinary building purposes, though stone suitable for the finer class of work is as yet quarried at but few places. Within the Silurian area, to which the more thickly-settled portions of the state pretty closely correspond, except where a very deep covering of glacial drift exists, there are but few regions where rock fit for the most ordinary building purposes cannot be obtained everywhere within a few miles, and almost every large town or city has within its limits, or near by, quarries of sufficient capacity to supply its own most pressing needs for that sort of building material; but there were previous to 1880 no localities (except at Bass island in the Lake Superior region) where building stone had been quarried in any quantity for export beyond the state, (*a*) and but few where it had been quarried for other than a local market. There are indeed but few places where the Silurian formations yield large quantities of easily-obtainable stone of such character as to be in very general demand. The Niagara group furnishes several of these places in the vicinity of Milwaukee; the Trenton group (Galena limestone), a number along the Lower Fox river and Duck creek, in Outagamie and Brown counties; the Saint Peter sandstone, a barely possible one at Red Rock, near Darlington, La Fayette county; the Lower Magnesian but one, at the Prairie du Chien quarries and in their immediate vicinity, Crawford county; and the Potsdam sandstone, in the Apostle islands, and possibly along the coast of Bayfield and Douglas counties.

Potsdam.—The main body of Potsdam sandstone in southern Wisconsin is made of a medium-grained, somewhat rounded, siliceous sand, the particles cemented together either by a fine siliceous powder of the grains themselves, or by a coating of carbonaceous or ferruginous cement. Where the first is the cementing material the stone is exceedingly friable and useless as a building material, but where the cementing material is either of the other two, the rock is generally of a compact and durable character and furnishes some excellent building stones. Sections of this formation in different parts of the state show a varying thickness, reaching as much as 700 feet in the central southern part. Of this the middle and by far the greater part is loose friable stone, much of it easily separated into sand by light blows. Exceptions to this occur in numerous places where the sandstone was deposited close

(*a*) A temporary exception to this statement occurred during a period of about two years after the Chicago fire, when such building stone was sent into Chicago from a number of quarries in southeastern Wisconsin.

to the Archæan area, as at the Stevens Point quarries, and those near Grand Rapids, at which last place the stone is a very valuable one, and is referred by Professor Irving to the middle portion of the Potsdam. Another exception of like character occurs along the quartzite ranges of the Baraboo region, where many facts go to show the probability of two separate sandstones laid down at different periods.

Wherever, along the quartzite ranges of that region, the sandstone is found resting immediately upon the quartzite it furnishes a medium grained, compact, massive sandstone of great durability, which can be quarried in very large blocks, is of uniform texture throughout, free from flaws, and of colors from light straw and nearly white through various shades of light pink, the varying colors being due mainly to changes in the cementing material. The two large quarries in this sandstone at Ableman's have furnished a very large amount of stone for bridge and culvert purposes along the line of the Chicago and Northwestern railroad. The hardness of the stone and consequent difficulty of dressing have so far prevented its use for general building purposes. There is a large number of localities throughout the same region where this stone occurs, and it everywhere presents the same character, and has in many places been quarried to the extent of a few cords.

The upper beds of the Potsdam also furnish in the southern part of the state two layers—one of sandstone underlaid by the other, an impure dolomitic limestone—which immediately underlie the Lower Magnesian limestone, and occur everywhere just below the base of that formation wherever the latter is exposed in the half circle in which it comes to the surface. These beds have been given the name of Madison sandstone and Mendota limestone.

The Madison beds, wherever they occur, are rarely less than 35 feet thick, often more, and furnish frequently a slightly calcareous sandstone, which is generally a very good building stone, although never occurring in layers of a thickness suited for large ornamental stone. It is of various shades, from yellow to a light dull brown, and has been much quarried wherever found, because of the ease with which it can be shaped into appropriate forms. It gradually hardens and changes upon exposure to a rather dull yellowish-brown, and has been quite extensively used at Madison and in the surrounding country, and in many villages in the region where it occurs.

The Mendota limestone is equally persistent in occurrence throughout the same area, and includes a total thickness of from 20 to 45 feet in different localities. It furnishes a stone varying from nearly white through all shades of yellow to dull brown, is quite regularly bedded, occurring in layers up to 5 feet in thickness, and is more extensively quarried than the Madison sandstone, since it can also be burned for lime, of which it furnishes a very fair quality. Wherever it occurs it furnishes valuable building material, especially for heavy work.

The Potsdam sandstone of the region of lake Superior is of a character somewhat distinct from that in southern Wisconsin. Its rock where exposed in Wisconsin is composed of siliceous grains, medium to somewhat coarse, held together by a cement usually either ferruginous or argillaceous in its character, and is generally stained from yellow to deep brown by the ferruginous matter. It furnishes a very handsome building stone, and is quarried in masses of almost any required size. The chief difficulty with the stone as a fine building material arises from the fact that it contains, wherever yet quarried, numerous clay pockets which are liable to badly pit the finished surface. They are likely to be found anywhere in the stone when it is worked, and where ornamental relief work is being done the nearly-completed piece is often entirely spoiled by opening into one of these pockets, or the completed piece is badly defaced by the subsequent breaking away of a thin skin of sandstone and the dropping out of the clay. The difficulties which arise in this way can, of course, be partly overcome by having all the cutting, shaping, and finishing done at the quarries, thus saving the cost of transportation of useless pieces. This characteristic of the stone has proved a great drawback to its general use. Many exposures from which the stone could be readily quarried and shipped directly upon vessels are found on the islands of the Apostle group, and some are found along the coast of Bayfield and Douglas counties.

At Bass island (Apostle islands) a large quarry was opened in this sandstone, and was extensively worked during the first three or four years of the last decade. Quite heavy stripping of clay is required, and below this there is exposed a quarry face of 26 feet of good stone; below this the stone is inferior. In this depth there are three layers which in places unite. The joints are inclined about 60° and are spaced about 50 feet apart. Between these and within the beds the stone is uniform in texture and color, and without seams or cracks. It is of very much the same grade as the Marquette stone, but free from its vexatious variations of color. The quarry has been abandoned for several years, and was not worked during the census year.

Lower Magnesian.—The Lower Magnesian limestone forms the surface stone over a very large semicircular band everywhere skirting the wide Potsdam belt. Its beds consist largely of a quite siliceous dolomitic limestone, sometimes nearly pure, the siliceous or arenaceous material sometimes predominating. In a great many localities it furnishes a rather rough and irregularly but heavily bedded limestone, a good material for heavy masonry, and it is quarried in a large number of places, though nowhere very extensively. In a few localities a very excellent building stone has been quarried from it, usually from its lower or lowest beds. The most noteworthy of the places are the southern part of the town of Westport, Dane county, just west of Bridgeport, near Prairie du Chien, Crawford county, and at the summit of the Mississippi River bluffs, in the vicinity of La Crosse, La Crosse county, and northward to a point across the river from Winona, Minnesota. In the town of Westport, Dane county, is a number of quarries of considerable size, not much worked during the census year, which were nearly all opened for the purpose of

supplying stone for the Insane Hospital building located in that township. They were opened in the lowest beds of the Lower Magnesian, just above its beds of separation from the Potsdam. The Venhusen quarry has supplied the greater part of the stone for the hospital building, a heavily-bedded, compact, hard limestone of rather fine but slightly uneven texture, in color varying from very light straw to light buff when dressed, and having occasional small sand-pits. This stone does not discolor upon exposure, and its chisel marks remain after more than 20 years apparently as sharp and definite as when the stone was first built into the wall. This quarry is a very difficult one to work because of very heavy stripping.

O'Malley's quarry, 1½ miles northwest and not far from the horizon, furnishes a whiter, clearer stone. A considerable thickness of good rubble stone is succeeded by some heavy beds, 28 inches thick, which were quarried for the face stone of the United States court-house and post-office at Madison. This is a hard, somewhat arenaceous, white, uniform-textured stone, which an exposure of over ten years in that building has only turned to a very delicate straw color. It was somewhat hard to dress, retains its chisel marks unchanged, and shows no tendency to scale off on the dressed surface.

[The trimmings of the post-office water-table caps, sills, joints, etc., are of selected stone from one of the Joliet, Illinois, quarries, and have scaled off in large thin scales, entirely defacing the tool marks.]

This stone is by far the handsomest stone quarried in southern Wisconsin, except at Waukesha, in the vicinity of Milwaukee.

There are several smaller quarries in these beds and numerous places in the locality where quarries equally good could probably be opened. The Chicago and Northwestern railway traverses the town, and is not farther than a mile from these quarries.

At the Bridgeport quarries, near Prairie du Chien, the Lower Magnesian limestone is also quarried quite extensively in Marsden's quarry. The beds quarried cannot be many feet above the base of the formations. They have a ledge near the crest of the river bluffs, just west of the village, which is there perhaps 80 feet above the river, and dips gradually westward, coming to the level of the river valley before it opens upon the Mississippi river. Numerous quarries have been opened in this ledge and large quantities of stone removed, but all the quarries except Marsden's have been abandoned, and an examination of them indicates that probably none of them could be worked profitably, except for an unusually favorable market. One or two places remain where good quarries could probably be opened.

The stone quarried from the heavier and more regular beds is a nearly white, somewhat creamy-tinted limestone, which does not iron-stain or change much upon exposure, except to take a slightly gray dust-colored hue. It dresses rather easily, and seems to harden somewhat on exposure. It is on the whole an excellent stone for all building purposes where a very fine finish is not required. This and the adjacent quarries furnished the stone for the state capitol, and from this quarry the stone for the extension of that building, now in process of construction, is taken. Large quantities of dimension stone are also now being shipped from here to Minneapolis, Minnesota, and much stone furnished for bridge work upon the Prairie du Chien and River divisions of the Chicago, Milwaukee, and Saint Paul railway.

On the bluffs next the river valley, and near their summit, in the region around La Crosse, there outcrops and is quarried a limestone (lower beds of Lower Magnesian) the lower beds of which yield a clear, creamy-white tinted stone, very fine-grained and of quite uniform texture, which makes a very handsome ornamental building stone. At some places it is pitted with occasional sand-holes, but at others stone of considerable size can be obtained free from these imperfections. It can be very readily worked into different shapes and even carved in fine figures in considerable relief.

There are doubtless many other localities where these lower beds of this formation yield equally good stones with those here described, but no other extensive quarries have, so far as I have been able to learn, been opened in them

Saint Peter sandstone.—The Saint Peter sandstone consists almost everywhere of somewhat rounded siliceous grains, sometimes entirely uncemented, forming beds of very pure sand, and sometimes cemented to a quite hard and durable stone, which is everywhere, however, where I have seen it exposed, very much cut up by irregular seams or joints, themselves filled with arenaceous material dividing the rock into angular fragments. The material of these seams, however, sometimes cements the fragments well together. The rock has some slight use as a building stone in the town of Portland, Jefferson county, and in the southwestern part of the state, but only for cellar-wall purposes.

At Red Rock, in the valley of the Pecatonica, in southern Iowa county, near Darlington, there is a remarkable exposure of this rock, which appears to have been an upheaval.

In the north side of this exposure a large quarry was opened in 1872 by William T. Henry, of Mineral Point, which was worked only one season. The stone was shipped to Chicago, but the heavy freight charges prevented the business from paying, and the quarry has remained unworked since. Better freight rates can now be had to Chicago and Milwaukee. Some of the stone has been sent to Chicago for trial, and it it meets with favor there the quarry is likely to be opened on a large scale. The stone can be obtained in blocks as large as 6 foot cubes, apparently without flaws. It is, however, much cut up by the fine, irregular seams alluded to above, and it seems

doubtful whether the desirable deep tint of brown is the color of more than a small portion. The stone in the railroad cut approaches a brick red in color, and this grades to a deeper color, nearly brown at the quarry spot, beyond which it gradually passes into a grayish tone. It is in general appearance much the handsomest building stone found in that part of the state, but some considerable stripping of worthless stone will be required should the quarry be extensively worked.

TRENTON GROUP.—The Trenton group in Wisconsin contains two rather distinct divisions—the Trenton limestone and the Galena limestone.

The Trenton limestone or blue and buff beds furnish, wherever they occur in the southwestern part of the state, in what is called the Lead region, an excellent and durable building stone, but not often a handsome one. The buff beds, the lower, occur in layers from 6 inches to 2 feet, and sometimes thicker, and furnish a rather coarse, hard, somewhat unevenly-textured stone which is not difficult either to quarry or to shape and work. Its color, owing to uneven leaching, is usually, or at least often, blue at the center of the layer, but a decided buff for some inches from the bedding planes, while often stone taken from near the natural surface is leached throughout to a buff color. The blue beds in that region usually furnish a very thinly-bedded, hard, dark grayish-blue to dark drab, fine-grained, often fossiliferous stone of pretty uniform texture, rarely occurring in layers thicker than 10 or 12 inches and not obtainable in very large blocks. At some places these beds remain unchanged by leaching, at others the leaching affects their color almost as much as it does the buff beds. They furnish very hard, durable stones, which are very hard to dress, but take a very fine, soft feeling polish, and often, because of the fossils included, present a very handsome appearance. These beds have been considerably worked at many points in the Lead region, as at Mineral Point, Darlington, Mifflin, Platteville, Highland, etc. There are, so far as I could learn, no quarries now worked on a sufficient scale, or enough distinguished in former working from hundreds of others, to warrant a special report.

In the adjoining parts of Saint Croix and Pierce counties there is a considerable area where the bluffs are everywhere capped by the Trenton limestone, often only the buff beds; and this is quarried in a number of places, notably at Gibson's quarry, near Hudson, and in Walker's quarry, at River Falls. They present here almost exactly the same physical characteristics as in southwestern Wisconsin, and furnish an excellent and durable though not a handsome building stone. Owing to their position close to the surface the beds are more generally leached to a solid buff color.

In the southeastern and eastern portions of the state the blue and buff beds present very little marked difference in texture and physical characteristics, the heavier and more regular beds being still characteristic of the lower beds or buff, and that being much the more profitable portion of the formation for quarrying. The blue beds generally furnish little or no material fit for other than the commonest masonry, while deep quarrying into the buff (away from the originally-exposed surface) often develops a bluish graystone of rather rough, uneven texture, but suitable for a fair quality of the ordinary ornamental building stone. The quarries in these beds in the eastern and southeastern parts of the state, upon which special report has been made, are those at Beloit, at Janesville, and at Neenah and Menasha. Along the line of its outcrop, as it passes from the northeastern part of the state southwest and then bends to the westward and southwestward, and also where it outcrops in the Lead region, are very arenaceous small quarries.

The upper bed of the Trenton group, the Galena limestone, is the surface formation over a large area in the Lead region and extends in quite a wide band southeastward into Illinois, then bends to the northward nearly parallel with lake Michigan, and at a distance of from 25 to 50 miles inland to and across the state line into northern Michigan.

In the central and eastern part of the Lead region the stone of this formation is everywhere of the same brown or yellow color, often much iron-stained, and also somewhat rotten and honey-combed throughout with large cavities often an inch or more in diameter, almost everywhere unfit for any building purpose, though sometimes compact enough for rough cellar-wall work, and is occasionally used for that purpose.

There are several horizons, however, at which, when it is exposed, it furnishes an excellent, heavily-bedded, rather coarse-textured, strong and durable building stone, well fitted for ordinary and heavy masonry. These beds outcrop at Cassville and along the Mississippi River bluffs in western Grant county, and in numerous other places in that part of the Lead region.

In the southeastern part of the state for some 60 miles north of the state line the Galena limestone has the same physical characteristics as distinguish it in the central part of the Lead region.

At Watertown, however, beds of sufficient firmness and freedom from honey-combing are found to furnish a fair building material. From here northward the stone gradually undergoes a change, mainly through the addition of argillaceous material, which very materially affects for the better its appearance and usefulness as a building stone.

At Waupun a large quarry was once worked in this formation, which furnished an excellent coursing stone.

At Oshkosh are two large quarries which furnish a dark drab stone of considerable hardness and durability, but which dresses with much difficulty, and has been little used heretofore for facing or for ornamental purposes.

Northward from here there are no noteworthy quarries in this formation until we reach the rapids in the Fox river at Kaukauna, where large quarries have been opened and great quantities of unusually large dimension stone taken out. Here is opportunity for opening many extensive quarries in stone of a most excellent character for all mason work, except that requiring the very finest of finish.

Many of the government locks on the Fox river have been built with this stone and others are to be built.

The stone is a medium textured, light drab or gray limestone, and occurs in beds from 6 to 30 inches thick, from any one of which it can be split in almost any required size, and it can be quarried for dimension material almost if not quite as cheaply as for rubble.

The quarries at Duck creek, on the Chicago and Northwestern railway, near Green Bay, are in exactly similar rock, and have furnished the railway with large quantities of a most excellent stone for bridge purposes.

NIAGARA GROUP.—The Cincinnati shales, *i. e.*, limestones, furnish no building stone. The only Upper Silurian formation in Wisconsin furnishing any building stone is the Niagara limestone. This formation is the surface rock in a strip of country 30 to 50 miles wide along the shore of lake Michigan. There are four well recognized subdivisions of the formation, which maintain the characteristics with considerable persistency throughout the whole country where the formation is exposed: 1. Guelph beds; 2. Racine beds; 3. Waukesha beds; 4. Mayville beds.

The lower of these, the Mayville beds, forming the surface rock in the country adjoining that immediately underlaid by the Galena limestone, contain some beds which furnish stones fit for ordinary building purposes, but no especially noteworthy quarries. In the upper part of these beds there is, in some places in Fond du Lac county and the counties immediately adjoining, a very pure calcareous sandstone, whose occurrence has been mentioned in the reports upon the quarries in the vicinity of Fond du Lac. It is a pinkish-gray stone of varying compactness, which cuts with very great ease and seems to harden some upon exposure. It would be a valuable building stone but for the fact that no spot has yet been found yielding a large quantity of stone of even a tolerably uniform character, or from which pieces of large size could be taken out.

The Waukesha beds throughout Waukesha county furnish a hard, compact, very light drab, sometimes nearly white dolomitic limestone, which yields an excellent, fine-appearing, and durable building stone suitable for all grades of construction. It is quite a hard stone to cut and finish, but presents a handsome appearance when dressed. The typical occurrence of these beds is in very thin sheets, from 1 inch to 6 inches thick, very well fitted for flagging, but these often unite to form much heavier ones, furnishing stones of almost any ordinarily required size. The quarry of the Hadfields, at Waukesha, is the largest and most worked, and sends considerable quantities of stone to Milwaukee and many other Wisconsin towns. In the quarries owned by these gentlemen the typical Waukesha beds yield flagging stones and heavily-bedded building stone. Throughout the country where these beds occur are numerous excellent quarry spots awaiting development. South of this point there is a considerable quarry, 2 miles from Genesee station, which furnishes some stone rather easier to work and somewhat freer from slight defects than the Waukesha.

Northward also from Waukesha these beds have been worked at a number of places and furnish fine flagging material especially. In the country to the northward where these beds emerge from under their intermediate heavy drift covering their stratigraphical equivalent presents three very well-marked divisions, the first only of which furnishes any considerable amount of valuable building stone. This division, called Byron beds, from having its most marked exposures in the town of Byron, Fond du Lac county, forms in that county what is called "the ridge" and "the ledge", a considerable rise of ground, with an abrupt and rocky western face, which runs southward, swinging somewhat westwardly, just east of Fond du Lac, and which is quarried at numerous places near that city, as, notably, at Eden and Oak Centre, and at Sylvester, in Green county. Here good building stone—a compact, medium to fine textured and quite homogeneous limestone—is obtained for ordinary and ornamental purposes, though somewhat hard to shape, and fine flagging stone of any required thickness between 1 inch and 8 inches. Many quarries have been opened in the ledge, but only a minute fraction of the easily-quarriable stone has been as yet uncovered. These beds pass to the east of lake Winnebago, through Calumet county, where they occur in places as a very pure white and sometimes handsomely-mottled stone, which is locally called marble, and can be polished fairly well, presenting a handsome appearance and being well fitted for ornamental building stone. The two upper divisions furnish very little material fit even for ordinary building purposes.

The Racine beds, which rest upon the Waukesha beds at the south and the upper coal beds at the north, are the surface rock along and parallel to lake Michigan, from the state line on the south to the extreme end of Door county on the north, attaining in places a width of 30 miles. They are beds of quite pure dolomitic limestone, and present a great variety of texture and structure, from a porous, granular, and irregularly-bedded to a fine, compact, homogeneous, and evenly bedded rock. They are very extensively quarried, and furnish most excellent common and fine building material at a great many points, notably at Milwaukee, Cedarburg, Grafton, Sheboygan, and Manitowoc. The Racine quarries in these beds have furnished large quantities of ordinary building stone and stone for lime, but very little material well fitted for ornamental and the finer classes of stones. The Milwaukee quarries furnish every grade of building material and almost any necessary size, and are remarkable for the great depth of excellent building stone which their working has developed.

The Guelph beds, forming the uppermost series of the Niagara group, have pretty much the same general physical characteristics as the Racine beds upon which they rest. In a number of places they furnish excellent building stones, similar to those of the Racine beds. They skirt the shore of lake Michigan as far north as Kewaunee county, and are somewhat quarried at Cedarburg and Grafton, and at Sheboygan.

The Niagara group as a whole furnishes by far the largest number of extensive quarries of any formation in the state, and almost the only ones, except the few in the Archæan, in which the depth of excellent stone is more than a few feet, and which therefore warrant the expenditure of large sums of money in removing the covering. For this reason the number of places in this formation where quarries can be profitably worked is very large.

None of these quarries as yet opened are in convenient proximity to the lake, so that the development of these, as well as of all those valuable Archæan quarries inland, will depend upon transportation facilities furnished by railroad companies.

ARCHÆAN.

The vast area in northern central Wisconsin which is underlaid by the Archæan rocks is almost everywhere covered with an irregular but heavy covering of glacial drift, and there are large areas where rock exposures are very rare. A large part of the stones of this formation are of a character unfit for building or ornamental purposes. Several localities have, however, been pointed out by Professor R. D. Irving in his report upon the geology of central Wisconsin (*Wisconsin Geological Report*, Vol. II) as likely to furnish valuable building and ornamental rocks.

At Little Bull falls, on the Wisconsin river at Mosinee, Marathon county, are large rock exposures of a greenish-gray mottled syenite, much of which would furnish a handsome and excellent building and ornamental stone, and which could be quarried with great ease. A very similar rock is found on the Eau Claire river, at the crossing of the Stevens Point and Wausau road, but is here coarser than that variety of the Little Bull Falls syenite which is best fitted for building purposes.

A short distance west of Wausau, in the southeast quarter of section 21, township 29, range 7 east, is a small granite quarry owned by Mr. Kolter, on which a special report has been made. The stone has some considerable local value. The ridge upon which this quarry is located extends 3 or 4 miles. A rock very similar to this is also found on the south side of the valley of Little Rib river, on the southeast quarter of section 29 in the same township, but it is not exposed.

At the falls of Rib river there is found a heavily-bedded greenish syenite, which breaks readily into rectangular blocks.

In the valley of the Wisconsin river, around Grand Rapids, Wood county, there are numerous exposures, natural and artificial, of reddish granites, some of which could be easily quarried for building stone, but most of them show a decided tendency to decompose upon exposure. At Grand Rapids there is exposed in the bed of the river, at low water, a deep red, handsome granite, which would probably have considerable value as a building stone, and could be quarried quite readily during times of low water. The amount of quarriable rock is not, however, very great.

In the valley of Yellow river are some exposures which merit special attention.

In Hemlock creek, at the crossing of the wagon-road from Grand Rapids to Dexterville, is a fine-grained, flesh-colored granite, which, though showing some tendency to weather and even to stain, would furnish a very handsome, readily-dressed rock.

On Yellow river, at Big Bull falls, on sections 15 and 16, township 24, range 3 east, are large exposures of a medium-grained red granite extending along the bed and banks for a quarter of a mile. It is an unusually fine stone, taking a handsome polish. Polished specimens were exhibited in the Wisconsin collection at the centennial exhibition at Philadelphia, where they were regarded as among the finest of the polished granites exhibited.

On section 3, township 22, range 3 east, 3 miles north of Dexterville, there is in the bed of the river a greenish-gray quartz-porphyry similar in texture to those of the isolated Archæan patches in the southern part of the state.

At Black River Falls there is in the bed and along the bank of the river a continuous and large exposure of medium-grained pinkish granite. There are several spots where extensive quarries could be opened. The Chicago, Milwaukee, Saint Paul, and Ohio railroad crosses the river at the town, and convenient facilities for loading and transporting the granite could probably be arranged for. Specimens of this rock were taken.

On Black river, in the stream, about 1 mile above Black River station, is a ledge 25 feet high and 150 feet long of fine-grained, dark reddish granite.

Above the mouth of its east fork there are exposures and ledges of red granite as far as to French's mill, in section 25, township 23, range 3 west. At the mill the exposures are large; the stone is reddish, fine-grained, and uniform-textured, and would make a handsome building material.

Three-quarters of a mile west of Neillsville, where the wagon-road crosses Black river, on southwest quarter of section 15, township 24, range 2 west, is a fine grained, light pinkish, slightly gneissoid and very quartzose granite, hard and compact, and which appears to be a very fine ornamental granite.

The gneissoid and red granites of Black and Yellow rivers resemble one another closely and appear to be directly continuous with one another underneath the sandstone, which nearly everywhere between the two rivers is the surface rock. Occasionally the crystalline rocks come to the surface in the interval, and are then of the same character as in the rivers, as for instance on O'Neill's creek, in section 182, in township 24, range 1 west, Clark county, where red granite is exposed; and on a high bluff in the northeastern part of township 23, range 2 east, whose upper portions are reported to be of red granite, with sandstone layers at lower levels. (*a*)

These notes show quite conclusively that there is in the southern and southwestern parts of the main Archæan area of central Wisconsin and its branches a large number of localities where are found granitic and syenitic rocks of excellent quality for building and ornamental purposes, in many of which the rock can be readily quarried, and it seems probable that in course of time these stones will find their way into the market.

Beside the main Archæan area there are in the southern central part of the state a number of small patches or islands of granite, quartz-porphyry, and quartzite projecting through the overlying Silurian rocks. Previous to the census year no regular quarrying had been done in these rocks, but at the close of that year a great demand arose in Chicago for paving stones of a durable character, which led to the opening and working for that purpose of several quarries in these outlines, which happened to lie near the means of transportation to that city.

Owing to their nearness to the thickly-settled portions and great cities of Wisconsin and Illinois, and to means of transportation, these small areas all seem likely to sooner or later become important centers of the quarrying industry.

At the present time the most important quarry of these areas is that at Montello, where a medium-grained, dark, rather dull pink granite is quarried. It was first opened chiefly to obtain paving stones for Chicago, but has from the first furnished considerable quantities of building and ornamental granite. The stone takes a fine polish, but owing to its small grain and the even distribution of the constituent minerals its appearance is not as showy or handsome as that of many other granites. It is a very durable and reliable stone, having also apparently great strength. The extent of quarriable rock is very great.

The quarry near the village of Waterloo, Jefferson county, in an outline of nearly white quartzite, is perhaps next in importance. It furnishes as yet only paving stones and macadam material. The paving blocks are split more smoothly and regularly than any others I have seen in Chicago from the east or from Wisconsin. They appear harder and likely to be more durable than those from the Montello quarry. An attempt is being made to get this stone out in large blocks adapted for building and ornamental purposes.

A quarry has been opened in the Moundville quartzite-porphyry, which also is worked only for paving blocks, all of which have as yet been sent to Chicago. Monroe street, from State street to Wabash avenue, in that city, has been paved with it. The stone is very hard and well suited for that purpose, and blocks out easily though somewhat roughly into pieces of requisite size. The stone takes a very handsome polish and is very dark, almost black, when so finished.

Some 5 or 6 miles from Portage, at the east end of the ranges, a quantity of jasper has been taken out, and some citizens of Portage are experimenting with it to learn its value. The pieces taken have been handsomely polished and present the appearance of beautifully-grained dark mahogany. I have been unable to learn whether the locality yields large quantities of this stone, and whether it can be obtained in blocks of considerable size, but I judge from reports that the only difficulty anticipated by the owners is that of properly shaping the pieces taken out.

The following description includes fuller statements as to some localities already named:

On the line of the Wisconsin Valley railroad, between Centralia and Junction City, are several deep cuttings, which expose usually crumbling and partially-decomposed laminated gneissic rocks. The exposures are very poor and the rock is generally out of position. About 3½ miles north of Centralia is a cutting 400 feet long, through a rather fine grained, granular-textured, pinkish granite. This rock consists of brownish, translucent, granular, glassy quartz largely predominating; pinkish bright-lustered feldspar, and fine black mica sparsely but uniformly scattered. It would dress readily, but shows some tendency to weather and iron stain.

At Little Bull falls, on the Wisconsin river at Mosinee, Sec. 29, T. 27, R. 7 E., Marathon county, are quite large rock exposures. The river here is divided into two widely-separated channels by a high, rocky island about a quarter of a mile in width. On its northeast end this island is itself cut by several smaller channels, dry at low water, which show high walls of bare rock. Most of the water of the river passes through the easternmost channel, which in one place, for a distance of 130 feet, is a gorge only 35 feet wide. The main fall of the river was formerly in this gorge, but has lately been moved down stream by a dam erected below. The rocks of the various exposures at this place are all closely allied and may be designated by the general term of syenite. They are all characterized by the presence of much greenish-black amphibole and white striated feldspar, the quartz, though present, being always subordinate. Two general kinds were noted. The prevailing rock is a moderately-coarse grained, highly crystalline syenite, with a greenish gray mottled appearance, and without any sign of parallel arrangement of the various ingredients, which are uniformly intermingled. On a weathered surface this rock appears greenish to white, the latter color being due to a kaolinization of the feldspar. On a fresh fracture the two main ingredients are readily perceptible to the naked eye. The hornblende is usually of a bright-lustered,

(*a*) [illegible] Vol. II, p. 504.

greenish-black color; the feldspar facets are commonly shade, translucent, and beautifully striated, as can readily be seen with an ordinary lens. More rarely porphyritic feldspar occurs. That variety of this rock which has a medium degree of coarseness presents a very handsome appearance on a dressed surface, and, since it shows no tendency to iron-stain or decompose, might make a valuable building stone. The second variety found here is very much finer in grain, and of a dark greenish-gray color, showing the crystalline texture only under the lens, and then not plainly. It is evidently merely a phase of the coarser rock. It occurs both in small embedded patches and in large, distinct outcrops. According to the microscopic examination these finer kinds, while having the same ingredients as the coarser, show a larger proportion of hornblende, and may be designated as "hornblende rock". Chlorite appears to occur in all, more especially in the finer kinds, as an accessory.

On the Eau Claire river, at the crossing of the Stevens Point and Wausau road, Sec. 7, T. 28, R. 8 E., there is a fall over coarse pinkish syenite resembling that on the Wisconsin river near the Mosinee hills, and also the prevailing syenite at Big Bull falls, a short distance northward.

On the upper Eau Claire, in Sec. 4, T. 29, R. 10 E., are exposures of a very coarse, rough-textured, feldspathic granite, consisting of pink, cleavable feldspar, very large-flaked black mica, and gray quartz.

Westward from Wausau, in T. 29, R. 7 E., a number of outcrops occur. Near its south line this town is traversed by Rib river. In Secs. 21, 22, 27, and 28 there is high ground trending north and south, which rises from 200 to 300 feet above the Wisconsin at Wausau. In the S. E. quarter of Sec. 21, on the south slope of part of this ridge, a peculiar, fine-grained feldspathic rock is exposed and is quarried to some extent on Mr. Kolter's land. This rock has a brownish-pink color, the least weathered portions showing a grayish tinge; it is rather fine grained, and has a marked granular texture, looking almost like a mechanical rock. The most abundant ingredient is a pinkish feldspar in cleavable fragments up to one-twentieth of an inch across. With this is much granular brownish quartz, and a little blackish mica in fine flakes, making the rock a granite. No arrangement of the minerals in parallel lines is perceptible. In the quarry the rock is seen to be nearly horizontal, dipping not more than 10° in a due south direction. A total thickness of about 3 feet was seen. Large thin slabs, from 2 to 4 inches thick, splitting off parallel to the bedding, can be obtained.

Near Single's mill, in the north part of the S. E. quarter of Sec. 29, in the same township, and on the edge of a part of the same high ground, are exposures of a whitish, slaty, granular quartzite, in places iron-stained. Under the magnifying glass this rock is seen to be made up of rounded grains of glassy quartz, and some few places were noted where the variety with granular texture grades into a non-granular, glassy quartz. Scales of silvery mica occur on the surfaces of laminæ. The bedding structure is distinct, and shows a strike of N. 75° E. and dip of 56° S. E.

About half a mile from this place, and on the south side of the valley of Little Rib river, S. E. quarter of Sec. 29, the northeast face of the ridge shows quartzite in large exposures. The rock here is glassy, translucent, and occasionally iron-stained, resembling that of Rib hill. The bedding is obscure. On the slope of the hill below, the roots of the trees of a heavy windfall have upturned numerous fragments of a brownish-pink, granular-textured feldspathic rock, similar to that at Kolter's quarry in Sec. 21. Half a mile northeast on the north face of the same elevation, N. E. quarter of S. E. quarter of Sec. 30, a high ledge shows the same feldspathic rock, striking N. 80° E. and dipping 50° N. W.

At the falls of Rib river, S. E. quarter of Sec. 28, T. 29, R. 5 E., are large exposures of greenish chloritic schist and syenite. On the south side of the river, at a point near the lower left-hand corner of Fig. 18, is a rocky point about 15 feet high, showing heavily but distinctly bedded greenish syenite, dipping 20° E. and striking N. 8° W. The uppermost layer, about 3 feet thick, is moderately-coarse grained, mottled green and gray, weathering white. To the lens it shows much grayish quartz, green amphibole, and white altered feldspar, the last least abundant, though coarsest of the three. In some specimens greenish chlorite accompanies the hornblende. The next layer below, 4 feet thick, is a very much finer grained, almost aphanitic, greenish-gray rock, containing apparently a good deal of chlorite. The weathered surface is white, with numerous green, epidote-colored blotches. Microscopic examination shows that the ingredients of this fine-grained rock are the same as those of the coarser one above, but that the amphibole and feldspar are both more altered. This rock breaks out very readily into rectangular blocks, the planes of easiest cleavage lying at right angles to the bedding. The lowest layer, 3 feet thick, is again of coarse variety like that of the uppermost bed.

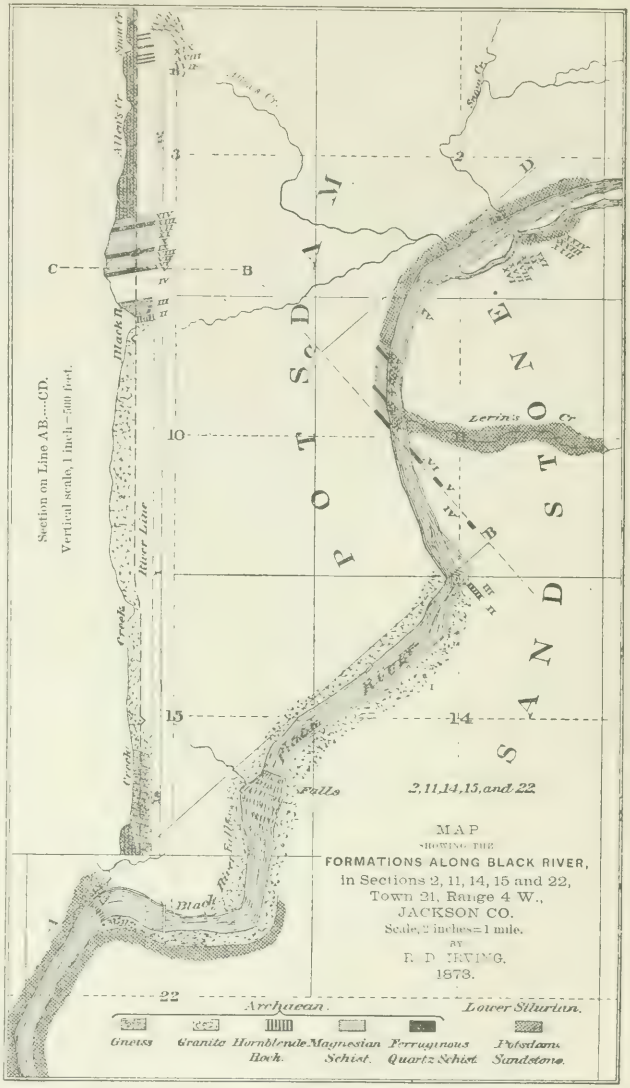
FIG. 18.

Scale, 1 inch=50 feet.

At Hemlock creek, at the crossing of the wagon road from Grand Rapids to Dexterville, in the N. E. quarter of the S. E. quarter of Sec. 5, T. 22, R. 4 E., are ledges of rather fine grained, flesh-colored, gneissoid granite. Translucent, wine-colored quartz, and pinkish orthoclase, in small brilliant facets, make up most of the rock; the mica is sparse, in fine, green-black flakes, which have a distinct linear arrangement. This rock is a handsome one, and would probably dress well, though showing some tendency to weather and iron stain. The bedding directions appear to show a strike of N. 60° E. and a dip of 70° S. E.

On Yellow river itself, the southernmost Archæan exposure is to be seen about 2 miles north of Dexterville, in the N. half of Sec. 14, T. 22, R. 3 E. The rock here is medium-grained, pinkish, quartzose, gneissoid granite composed chiefly of limpid quartz and orthoclase feldspar, the former the most abundant. Mica is present in fine black scales arranged in parallel lines. The strike appears to be N. 55° W. and the dip 60° S. W. Near the top of the river bank, which rises directly from the granite, thinly-bedded, friable, horizontal sandstone is exposed.

On Sec. 3, T. 22, R. 3 E., 3 miles north of Dexterville, there are large flat ledges of gneiss in the bed of the river, bounded on the north by quartz-porphyry. The gneiss is very fine grained, laminated, dark gray to black in color, and consists of a black mineral (mica, hornblende, or both), in small brilliant flakes; and whitish quartz and feldspar. Its weathered surface is earthy and of a dirty white color, but shows the fine lamination even more distinctly than the interior. The quartz-porphyry consists of a light greenish-gray, aphanitic matrix, having the peculiar flaky appearance that is characteristic of the quartz-porphyries of the various isolated Archæan patches of Wisconsin, in which are embedded somewhat sparsely scattered facets of pinkish orthoclase feldspar up to one-sixteenth of an inch in diameter. It is a very tough, compact, rock, and is worn by the running water into smoothed and polished surfaces. This porphyry appears to penetrate the adjacent laminated rock in a very irregular manner. In one place a mass of the gneissoid rock some 50 feet in diameter is nearly surrounded by the porphyry, the lines of junction between the two being very sharp, and rendered especially noticeable by the different appearances of their weathered surfaces. The lines of junction are not curved, but straight, bearing respectively N. 70° W., W. 20° E., and N. 70° W., the first and last upon opposite sides of the inclosed mass. The strike of the gneiss is N. 25° W., its dip 60° N. E. The porphyry is from 20 to 30 paces wide, and appears to be bounded on the north by the same gneiss as before, with the same bedding. Beyond, porphyry comes in again.



At Big Bull falls, 9 miles north of Pitt's mill, on Secs. 15 and 16, T. 24, R. 3 E., large exposures of medium-grained, highly feldspathic, red granite extend along the bed and in the banks of Yellow river for a quarter of a mile. This granite has a base of cleavable reddish orthoclase, throughout which is quite uniformly distributed hyaline, occasionally smoky, and quartz in irregularly-shaped patches from one thirty-second to one quarter of an inch in diameter. Mica is present, but is very fine and sparse. For the whole length of the exposure this rock is nearly uniform, and without any tendency to kaolinize. Its peculiar texture, composition, and color combine to make it a very valuable and unusually handsome building granite. Polished specimens of the rock attracted great attention at the Philadelphia exposition, where it was regarded by experts as among the finest of the many polished granites exhibited.

On Sec. 7, T. 24, R. 3 E., another exposure of a similar red granite was noted. Above this point Yellow river is reported without exposures.

BLACK RIVER VALLEY.—The first exposures of crystalline rocks met with in ascending Black river are found a short distance below the town of Black River Falls, T. 21, R. 4 W., in Jackson county. From here they occur in the bed and on the sides of the stream, with only occasional interruptions, as far north as town 28, in Clark county. For the greater part of this distance they are concealed away from the river by overlying horizontal sandstone, through which, however, they occasionally rise in knobby projections. In some of the branch streams also the sandstone is cut through and the crystalline rocks exposed. Along the river the rock ledges in few places only rise to any considerable height above the water.

Granite: Medium-grained pinkish, consisting of a nearly uniform admixture of pinkish orthoclase, in facets up to one-sixteenth of an inch, and fine-grained, translucent quartz. Some mica is present, in fine scales, showing sometimes a slightly stringy arrangement. This granite is exposed from a short distance above the wagon bridge as far north as the north line of Sec. 14, the river in this distance passing through a gorge whose walls sometimes reach a height of 80 feet. In the large exposures at the falls the parallel grain of the gneiss below is almost entirely lost, being only occasionally indicated in an obscure arrangement of the mica. The rock here is traversed by several sets of joints, mostly somewhat irregular, those showing the greatest irregularity trending N. 80° E. and dipping 72° S. E., but having no corresponding structure in the rock. The granite shows the same general character above as at the falls, occasionally—as in the railroad cut on the west side of the river, just above the falls—showing a darker kind than usual from a greater quantity of fine dark mica. In this cut there are to be seen two sets of planes equally marked, one set trending N. W. and dipping N. E., the other trending N. E. and dipping N. W. A distinct stringy arrangement of the mica was noted parallel to the former set. Near the north line of Sec. 15 the granite exposures cease suddenly on the east side of the river, while they continue some distance farther on the west side—a fact to be explained by the northwest strike of the succeeding slaty rocks.

In the river one mile above Black River station on the Green Bay, Winona, and Saint Paul railroad, a ledge 150 feet long and 25 feet high is seen of fine-grained, dark reddish granite, consisting of a rather uniform and close admixture of reddish orthoclase, in fine glittering facets, reddish-brown, translucent quartz, some colorless quartz, and a little, sparsely scattered, fine black mica. Half a mile farther up stream, fine-grained red and gray banded quartzose gneiss is exposed. The gray bands consist of fine-grained, glassy quartz, fine black mica, and white feldspar; the red of brown and red translucent quartz mingled with a little orthoclase. From here to the mouth of the East fork the bed of Black river shows numerous small ledges, 3 to 4 feet high, of contorted gneiss and reddish granite.

Above the mouth of the East fork, which is on Sec. 36, T. 23, R. 3 W., exposures of red granite are seen as far as French's mill, on Sec. 25. The wagon-road, which for half a mile below the mill follows the west bank of the river, has, on the east side, ledges of red granite and on the west a ridge 30 to 40 feet high composed of horizontal, coarse-grained, quartzose, cross-laminated sandstone. In one place the exact junction of the two formations is to be seen. At the mill the granite exposures are especially large, both on the west bank and on a large island in the stream. Two kinds of the granite occur, both presenting a prevailing pinkish weathering: (1) a rather fine-grained, very uniform-textured, dark reddish kind; and (2) a medium-grained, uniform-textured, pinkish-gray quartzose kind, containing colorless, glassy, and pink translucent quartz, pink orthoclase, and fine black brilliant mica. Both kinds appear like handsome building or ornamental granites. No definite bedding structure is to be seen.

Three-quarters of a mile west of Neillsville, at the crossing of Black river, on the S. W. quarter of Sec. 15, T. 24, R. 2 W., fine-grained, light pinkish, slightly gneissoid, and very quartzose granite is exposed, with a vertical dip and E. W. strike. This rock is very hard and compact, and appears to be a fine ornamental granite.

The gneissoid and red granites of Black and Yellow rivers resemble each other very closely, and appear to be directly continuous with each other underneath the sandstone, which nearly everywhere between the two rivers is the surface rock. Occasionally the crystalline rocks come to the surface in the interval, and are then of the same character as on the rivers; as, for instance, on O'Neil's creek, in Secs. 1 and 2, T. 24, R. 1 W., Clark county, where red granite is exposed; and on a high bluff in the N. E. part of T. 23, R. 2 E., whose upper portions are reported to be of red granite with sandstone layers at lower levels.

The amount of these reddish ornamental granites of extraordinarily fine quality occurring on Yellow and Black rivers and in the intervening country appears to be very great.

The following table indicates the location, size, nature, etc., of the various Archæan outcrops in the Silurian area of the state:

ARCHÆAN OUTCROPS WITHIN THE SILURIAN AREA.

No. on the Fig. page 238.	Name of outcrop.	LOCATION.				Approximate area.	Height of bluff.	Nature of rock.	Distance from main Archæan.
		Sec.	T.	R.	County.				
							Feet.		
I	Baraboo bluffs	.....	.....	.....	Sauk and Columbia.	75 square miles	100 to 700	Quartzite, quartz-porphyry, clay-schists, and quartz-schists.	60
II	Lake mills	24, 25	8	13 E	Jefferson	20 acres	Low.	Quartzite	90
III	Portland	33, 36	9	13 E	Dodge	$\frac{1}{16}$ square mile	50 to 75	Quartzite	84
IV	Necedah	19, 24	18, 18	4 E, 3 E	Juneau	$\frac{1}{8}$ square mile	175	Quartzite	28
V	South bluff	21, 22, 23, 25	21	2 E	Wood	3 square miles	200+	Quartzite?	10
VI	North bluff	1	21	2 E	Wood	$\frac{1}{8}$ square mile	200+	Quartzite?	6
VII	Observatory hill	7	14	10 E	Marquette	$\frac{1}{8}$ square mile	250	Quartz-porphyry	48
VIII	Moundville	5, 8	14	9 E	Marquette	$\frac{1}{16}$ square mile	40	Quartz-porphyry	48
IX	Marcellon	7	13	10 E	Columbia	$\frac{1}{16}$ square mile	75	Quartz-porphyry	52
X	Marquette	34, 35, 2	15, 14	11 E, 11 E	Green Lake	$1\frac{1}{2}$ square miles	75	Quartz-porphyry	50
XI	Pine bluff	36	15	13 E	Green Lake	$\frac{1}{8}$ square mile	100	Quartz-porphyry	54
XII	Pine bluff	2	17	11 E	Green Lake	$\frac{1}{20}$ square mile	100	Quartz-porphyry	30
XIII	Berlin	2, 3	17	13 E	Green Lake	$\frac{1}{4}$ square mile	50 to 75	Quartz-porphyry	30
XIV	Montello	9	15	10 E	Marquette	$\frac{1}{16}$ square mile	40	Granite	42
XV	Spring lake	27	18	11 E	Waushara	$\frac{1}{8}$ square mile	50	Granite	27
XVI	Marion	12, 13, 7, 18	18, 18	11 E, 12 E	Waushara	$\frac{1}{8}$ square mile	50	Granite	26
XVII	Waupaca	31	22	12 E	Waupaca	$\frac{1}{8}$ square mile	100	Granite, etc	.....
XVIII	Mukwa	25, 26	22	14 E	Waupaca	$\frac{1}{8}$ square mile	70	Granite	.....
XIX	Iron mound:								
	No. 1	31	22	3 W	Jackson	$\frac{1}{16}$ to $\frac{1}{4}$ square mile	75 to 200	Ferruginous quartz-schist	.....
	No. 2	1	21	4 W					
	No. 3	12	21	4 W					
	No. 4	17, 20	21	3 W					
	No. 5	14, 15	21	3 W					

Baraboo bluffs.—On the northernmost portions of the northern of the Baraboo ranges at the lower narrows of the Baraboo river, T. 12, R. 7 E., and also for a short distance to the westward, a great thickness of quartz-porphyry is to be observed. This porphyry resembles that of the several small porphyry areas of the adjoining portions of Columbia, Marquette, and Green Lake counties, and proves at once that we must regard these areas as part of the same formation as that which appears in the Baraboo ranges.

On Secs. 23 and 26, T. 12, R. 7 E., Sauk county, the Baraboo river passes the north quartzite range in a gorge known as the lower narrows of the Baraboo. The passage is nearly half a mile in width, the level bottom extending to the foot of the cliffs on either side. The cliffs rise 400 feet above the river, and show finely the great

beds of quartzite and associated strata. The gorge is much wider than needed by the small stream that now occupies it, and may, as already suggested, have been at one time used by the Wisconsin, as the valley of Devil's lake seems to have been. It is unlike the latter valley in having been, in part at least, formed first before the Potsdam period, as indicated by the way in which horizontal sandstone and conglomerate ledges occur around the heads of steep ravines that extend down the cliff toward the main gorge.

FIG. 29.

MAP OF THE LOWER NARROWS OF THE BARABOO.
Scale, 1 inch = 1 mile.

Beginning with the north end we find, forming the north face of the range, in bold northward-sloping ledges, quartz-porphyry about 600 feet in width. This porphyry is for the most part dull red to pinkish on the weathered surface, which is a good deal altered, often iron-stained, and has generally a whitish undercrust. The least altered specimens show a brownish-pink matrix, through which are scattered, very thickly, large facets, up to one-eighth of an inch in diameter, of bright red cleavable feldspar, and, more sparsely, minute facets of a white kind. In nearly all specimens a few small greenish-black blotches, apparently composed of fine mica scales, occur, as also small iron-stained cavities, which often show linings of minute quartz-crystals. The porphyry is very distinctly bedded, showing an E. W. strike, and a dip of 58° to 60° N. Toward its lowest portions, and higher up on the bluff, it becomes gradually more slaty in character, the feldspar facets, though very numerous, becoming at the same time less well defined, and the surfaces of the laminæ becoming covered with a soft, greasy mineral. This finally changes to a distinct schist, (a) about 80 feet wide, containing a large proportion of the soft mineral, and allied to the greasy quartz-schists occurring at Devil's lake, but without transverse cleavage. Continuing the ascent of the bluff southward quartzite is seen lying immediately underneath the schist and forming the body of the ridge to the foot of its southern slope. At first this quartzite is much veined and seamed with reticulating veins of white quartz, in which fine specular iron is occasionally to be seen.

Marcellon.—On Sec. 7, in the town of Marcellon, Columbia county, on each side of the road in the south half of the section, are two low, rounded hills, 40 to 60 feet in height, of quartz-porphyry. The rock exposures are large and are much rounded and weather-worn, being separated into numerous bowlder-like masses by wide-open, earth-filled joints. The weathered surfaces have a prevailing pinkish tinge, giving the idea that the rock is largely composed of pink feldspar. On obtaining a fresh fracture, however, only a very few, sparsely scattered, minute feldspar faces are to be seen, the mass of the rock being composed of a brownish to blackish compact matrix. Two general varieties occur, one presenting a light brownish color, showing a tendency to flake off in fragments that are translucent on the edges, and containing no distinguishable feldspar crystals, the other having a dark gray to black matrix, in which are to be seen a few distinct crystals of feldspar and numerous copper-colored points of iron-sesquioxide. The rock has nearly the hardness of quartz, and fuses only with the greatest difficulty. A more siliceous character as compared with other quartz-porphyries of the state is thus indicated, and the indication is borne out by the content of silica—76.98 per cent.—as shown by analysis. We have evidently, in this case, a porphyry which, in its large contents of silica and in the sparseness of its feldspar crystals, approaches the true felsites (petrosilex hälleflinta). Quite a distinct and uniform set of bedding joints occurs, the strike being N. 32° E., the dip 65° to 75° N. W. Numerous cross joints traverse the rock, and, on weathered portions, cause it to fly into smooth-faced, angular fragments at the least blow of the hammer. The surrounding country is occupied by the Potsdam sandstone, which is exposed at many points.

Observatory Hill.—Six miles north of the Marcellon outcrop, in the S. E. quarter of Sec. 7, in the town of Buffalo, Marquette county, a knob of quartz-porphyry rises 250 feet above the general level and 490 feet above lake Michigan. On the flanks of the hill and up to a vertical distance above the base of 125 feet are horizontal sandstone ledges; above, to the top, are nearly continuous outcrops of porphyry, with a not very plain N. 32° E. strike and 60° N. W. dip. These bedding directions are the same as on the Marcellon outcrop.

Moundville.—On the edge of the Fox River marsh, at the head of lake Buffalo, on the line between Secs. 8 and 5, T. 14, R. 9 E., Moundville, Marquette county, are three low, rounded outcrops of quartz-porphyry. These are 5 miles, in a direction 10° N. of W., from Observatory hill, which is the nearest Archæan outcrop. No other rock shows in the neighborhood, the country being heavily drift-covered. The largest outcrop is on the east end of a low bluff 35 feet high and several hundred feet in length. There are quite marked appearances here of the same N. E. strike and N. 60° dip as seen at Observatory hill and in Marcellon. The rock has a dark brown matrix, resembling in this regard the Marcellon porphyry, from which it differs, however, in showing throughout traces of crystalline structure, and quite thickly scattered large brown feldspar surfaces. A few crystals are white and translucent. The weathered surface is often a bright pink color. Mr. Wright's microscopic examination shows that fine magnetite particles are abundant. Their existence is not rendered evident even by the use of the ordinary lens. The silica content is 72.76 per cent.

(a) This schist is probably non-magnesian, like the schists of Devil's lake, ordinarily called talcose.

Seneca (Pine Bluff, R. 11 E..—A rounded elliptical knob of quartz-porphyry, 100 feet high, one-eighth of a mile long, and a quarter of a mile wide, lies on the north side of the White River marsh, in Sec. 2, T. 17, R. 11 E., Seneca, Green Lake county. The greatest extension of the hill is in an east and west direction. It is largely rocky, but there are no abrupt rock ledges, the exposures being almost entirely surfaces conforming to the general contour of the hill, and on a level with the surrounding soil. In places the slopes of the hill are covered with angular fragments apparently split off by frost. This is a peculiarity not noticed upon any of the other porphyry outcrops, and appears to be due to the large content of comparatively coarse cleavable feldspar. The hill is only about 2 miles south from the granite hills of Spring lake, in T. 18, R. 11 E., Waushara county. The surrounding country is marshy and drift-covered, and shows no outcrop of horizontal rocks. The loose fragments are many of them smoothed on one side, and some surfaces are most beautifully striated. Owing to the broken condition of the outcrop, no definite bedding planes were made out, though weathered specimens brought away show distinct traces of lamination.

This porphyry in its least weathered portions shows a light gray to whitish fine-grained matrix, in which, with the lens, can be seen what appear to be angular grains of quartz. The glassy feldspar crystals are also abundant. The weathered surface is brownish, with a kaolinized undercrust. Nearly all of the rock shows signs of weathering. The silica content is 76.39 per cent.

Marquette and Berlin.—The large outcrops of quartz-porphyry in Secs. 34 and 35, T. 15, R. 11 E., and Secs. 2 and 3, T. 14, R. 11 E., near the village of Marquette, Green Lake county, were originally regarded as within the central Wisconsin district, of which, however, by subsequent agreement, the Fox river was made the southern boundary. They will, therefore, be described by Professor Chamberlin, in whose district is also the outcrop at the city of Berlin, Green Lake county. As the writer has examined both localities carefully, he may be permitted to allude to the nature of the rock of each, for the sake of comparison. In the Marquette outcrops the prevailing rock noticed has a black, compact, flinty matrix, which is streaked with white non-continuous lines. These lines are for the most part very prominent, and are frequently much contorted, the whole rock having a very evident parallel grain. The feldspar crystals are minute and sparse. The silica content is 70.29 per cent, less than that of any other of the Wisconsin porphyries. The general course of the contorted laminæ points to the same N. E. direction of strike as is observed on the Marcellon, Observatory Hill, and Moundville outcrops.

The Berlin rock has a dark bluish-gray matrix, much streaked with white, and having a peculiar fine, granular, quartz-like texture as seen under the lens. The feldspar crystals are small, grayish to brownish, and rather numerous. The lamination is very fine and distinct, and often contorted, and the silica content 74.37 per cent.

Montello.—In the village of Montello, on the west side of Sec. 9, T. 15, R. 10 E., Marquette county, is an elliptical-shaped, rounded mound of pink granite, about a third of a mile in length and 40 feet high. Over most of the hill the rock is quite uniform in a fresh fracture, though presenting a weathered surface from bright pink to dull grayish-pink in color. The weathering is very slight, however, and the rock shows almost no tendency to decompose. It has a medium grain, close texture, is of a bright pinkish color, and without sign of arrangement of the ingredients in lines. These are: Rather large flaked, pinkish, cleavable feldspar, predominating; somewhat granular, fine, pinkish, translucent quartz, abundant; and greenish-black mica sparsely scattered in blotches made up of very fine flakes. In places thin, light green, epidote-colored seams occur. Somewhat irregular northwest joints traverse the rock, which is, however, for the most part structureless, and is quarried by firing the pieces that crack off, presenting a conchoidal fracture. On the north side of the west end of the mound occurs a vertical layer 3 feet wide, trending N. 55° E., of a soft, greenish, highly schistose, decomposing, chloritic rock. The least weathered specimens show a blackish color and some tendency to a crystalline texture. The vein is weathered down for 2 or 3 feet below the inclosing granite walls, both of which are seen. The schistose laminæ are parallel to the walls. Greenish epidote seams in the rock near by have the same trend as the vein. Though this granite may be somewhat difficult to obtain in dressable masses, it would probably make a very handsome and durable building and ornamental stone.

Necedah.—Dotting the great sand plain of the Wisconsin in Juneau and Adams counties are numerous bold, castellated outliers of the Potsdam sandstone rising abruptly from the plain and constituting very marked features of the scenery. From the same plain, and only about 3 miles west from one of the greatest of the sandstone bluffs—Petenwell peak—rises the quartzite hill at the foot of which the village of Necedah is built. The rounded contour of this hill serves to mark it at once as different in nature from the sandstone bluffs of the adjoining region.

The main Necedah bluff lies on the N. W. quarter of Sec. 25, T. 18, R. 3 E., the town line crossing over its eastern end; it is about half a mile in length, with its greatest extension east and west, and is highest and at the same time most bold and rocky on its eastern end, which rises 170 feet above the street below and about 510 feet above lake Michigan. A short distance southeast of the main bluff, on the N. W. quarter of the S.W. quarter of Sec. 19, T. 18, R. 4 E., is a small, craggy hill, 75 feet high, of the same rock as that composing the main hill, the intervening low ground being underlaid by horizontal sandstone.

The exposures on the main hill are mostly on the eastern and southeastern portions, where in places they rise nearly precipitously from the low ground at the foot. The rock seen here is for the most part a glassy, translucent, subgranular, grayish quartzite, much more nearly allied to the quartzite of the Rib and Mosinee hills, in Marathon county, than to that of the Baraboo ranges. Much of the rock is quite dark gray in color, the quartz then

being still glassy, but smoky-tinted. Numerous small cavities and seams occur lined with half crystalline quartz and carrying a soft, pinkish, clayey substance; bluish-white quartz veins, ½ inch to 2 inches in width, and nests are also common, and these carry frequently fine-flaked, brilliant, specular iron, which occurs also occasionally in quite large masses, similar to those found in the Baraboo quartzite. No parallel grain is to be seen in this rock, nor any definite bedding planes. Numerous quite close joints occur, however, and these cause the rock to weather into smooth faced, sharp-angled fragments. On the smaller bluff a very distinct parallel grain is to be seen trending N. 75° W., and showing a corresponding dip of 45° N. Here much of the quartzite is of a light pink color, looking, on a fresh fracture, almost like a fine-grained, pinkish granite, but the only prominent mineral is subgranular, translucent, pinkish quartz. Some specimens show mica plainly in very sparsely scattered small scales. In many places little centers of iron-staining seem to be decomposing mica scales. Other portions of this rock are opaque, white, and distinctly granular, and are seamed with fine black lines, arranged so as to show discordant stratification. These seams, when split open, appear to be composed of blackish mica. Bluish-white veins and nests occur here also.

Marion.—In the town of Marion, T. 18. R. 11 E., Waushara county, are three low granite knobs. Two of these, Stone and Pine bluffs, are on the N. E. quarter Sec. 27, about two miles in a N. N. W. direction from the quartz-porphyry hill of the town of Seneca, Green Lake county; and the third, a larger and bolder hill, lies on the eastern border of the marsh, on Secs. 12 and 13, and stretches to some extent over the line into the town of Warren. On all of these areas the rock observed is nearly the same, a pinkish, feldspathic granite, mottled with gray and green, closely resembling the Montello granite, from which it differs, however, in having a coarser grain, a less close texture, and a marked tendency to decompose. Reddish cleavable feldspar is the principal ingredient, occurring in facets up to one-eighth and one-quarter of an inch in diameter; quartz is abundant, fine, granular, and translucent; mica is sparse, and scattered in small greenish-black blotches. Large whitish porphyritic feldspar occurs. There is no sign of any arrangement of the ingredients or of any parallel grain to the rock. No definite bedding planes were observed on any of the outcrops, though numerous crossing joint planes occur, and quite regular flat slabs are sometimes obtainable. Veins of white quartz occur. The most marked characteristic of the rock is its tendency to weather and shell off in crumbling masses. Some of the large flat surfaces are so far crumbled as to be penetrated readily by a horse's hoof. The rock from these outcrops would polish easily, but its tendency to crumble renders it less valuable than the Montello granite.

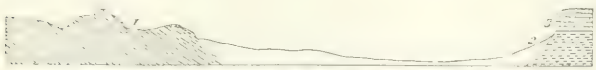
The following regarding this state is from the report on Eastern Wisconsin, by T. C. Chamberlin:

Mukwa.—The isolated outlier found in the S. E. quarter of the N. E. quarter of Sec. 26, and the N. W. quarter of the S. W. quarter of Sec. 25, town of Mukwa, Waupaca county, lies nearest the main Archæan area. This outcrop seems to have been unknown to the geologists heretofore, and came to my attention through information derived from Mr. Carr, of New London.

It consists of three large, and as many small, rounded, elongated, dome-like outliers, arranged nearly in a line trending W. 35° to 40° N., and rising near the center to a height of nearly 70 feet.

The rock consists chiefly of red feldspar, with which is associated a less quantity of quartz and a small and varying amount of a dark mineral, which was not seen in the distinct crystalline form, but which seemed to be an aggregation of minute blended blades of biotite. The crystals of feldspar are never large, seldom exceeding a quarter of an inch in length, and are usually quite minute, so that some portions, from which the dark mineral is absent, closely resemble red quartzite in appearance. The rock is intersected in various directions by veins of quartz. It is also cut into pyramidal masses by smooth, straight fissures, which are usually inclined at an angle of from 60° to 85° to the horizon. In trend these fissures constitute three groups: the first nearly north and south; the second nearly east and west; and the third northwest and southeast. There are also large irregular fissures, and occasionally points are to be observed from which an unusual number, both of the smooth and the irregular ones, seem to radiate.

Fig. 17.



PROFILE SECTION SHOWING THE RELATIONS OF THE MUKWA GRANITE.
1. Outlier of granite. 2. Potsdam sandstone. 3. Lower magnesian limestone.

The rock is very little affected by weathering, and affords an excellent building material, though the form of the blocks is unfavorable, and it is somewhat hard to dress.

No rock was found in contact with it, but about half a mile to the southeast, in the line of its trend, the lower magnesian limestone appears, into whose horizon the outcrop rises, though it lies chiefly in that of the Potsdam sandstone, as shown in the accompanying profile.

Berlin.—At Berlin, 30 miles south of the above, we next find an outstanding Archæan mass, (*a*) consisting of three large elongated domes arranged *en échelon*, bearing northeast. The rock is composed essentially of small crystals of orthoclase feldspar disseminated through a peculiar crypto crystalline base of felsite and quartz, forming a quartz porphyry. The crystals of feldspar are usually grayish before weathering, becoming reddish afterward. The base

a Comp. Dr. Percival's Report of 1856, p. 106.

in its unweathered state very much resembles quartzite, and is of dark grayish cast with a very slight reddish tinge, so modified by its translucency as to give to the whole what may be called a water hue. Very thin splinters may be fused before the blow-pipe with difficulty, forming a transparent glass-like bead. The effect of weathering is marked and peculiar. The color changes to a light reddish, pinkish, or grayish white, and occasionally to a bright red, while the mass becomes opaque and finely granular, and so soft as to be easily cut. There are occasionally spots, streaks, or leaves of dark material in the base, which are doubtless the portions referred to by Dr. Percival as "interlaminated hornblende and mica".

The rock is very uniform in character at all points exposed. It presents an obscure parallel structure giving rise to a somewhat definite system of cleavage, but traces of distinct bedding were not observed. The mass is traversed by extensive fissures, which are readily arranged in three groups, the predominant one of which bears northwest, and the smaller ones east of north and north of east, respectively, thus dividing the horizon into nearly equal arcs; but none seem to be dependent upon the cleavage structure of the rock.

Pine Bluff, R. 13 E.—Seventeen miles south of Berlin there rises out of the flood-plain of the Grand river a conspicuous mass of quartz-porphyry known as Pine Bluff. It ascends by steep and even precipitous acclivities to a height of 100 feet, and being entirely isolated from the surrounding elevations, and largely bare of soil and vegetation, becomes a striking object. The rock consists of white-gray and flesh-colored crystals of orthoclase and of glassy feldspar set in a very hard gray or black quartz-felsite base. The crystals of feldspar vary in size from three-tenths of an inch in length downward, but are rendered conspicuous by contrast of color. The rock is susceptible of a very high and beautiful polish, but is wrought with difficulty on account of its hardness. The dip is about 20° to the east of south. Obscure glacial striæ, still preserved, testify to its endurance. Their direction is south 45° west. The accompanying profile exhibits its relation to the Silurian formations, from which it will be seen that it rises to about the base of the Galena limestone.

FIG. 19.

NORTH AND SOUTH SECTION THROUGH PINE BLUFF.

1. Quartz-porphyry, Pine Bluff. 2. Lower magnesian limestone. 3. St. Peter sandstone. 4. Trenton limestone. 5. Galena limestone.

Marquette.—Near Marquette, a little more than 12 miles west of Pine Bluff, very similar quartz-porphyries display themselves in more considerable force, constituting a group of prominent hills. A portion of the rock is precisely identical in character with that of Pine Bluff, and the greater mass is but an unimportant variation from it, but certain portions depart from the porphyritic character, and become almost or entirely crypto-crystalline. One variety of this kind very closely resembles the more homogeneous of the red Huronian quartzites, and another is a compact, close-textured rock, usually of dark color, but sometimes greenish. Neither of these varieties occupies exclusively any one horizon, but the quartzite-like variety is found in the more southern outcrops, the last-mentioned kind immediately north of that, the darker porphyries next, and the coarser, lighter-colored ones in the most northerly exposures.

The bedding is very obscure, but the laminations of certain portions and belts of particular varieties of rock show the strike to be northeastward. The dip is made out with much less certainty, but appears to be to the northward, and to vary from 15° to 45°.

Though the Berlin porphyry differs from that of Pine Bluff and of Marquette in the absence of glassy feldspar, yet the close lithological alliance of the three is very evident, and they doubtless all belong to the same group of the Archæan series. The general strike of these formations, projected westward, encounters several similar outliers that are described in Professor Irving's report, and still farther southwest he has found similar quartz-porphyry overlying the Baraboo quartzite. There seems to be sufficient reason for regarding the latter as Huronian, so that the porphyries must be regarded as a newer portion of that formation.

All of these masses present the rounded contour of glaciated surfaces, and still bear the glacial groovings, and, in some cases, even remnant polished spots, and from all these trains of porphyry bowlders stretch away in the direction of the striæ.

Portland and Waterloo.—Thirty-five miles south of Pine Bluff, over an area entirely covered by Paleozoic rocks, some as recent as the Galena, we again encounter the Archæan rocks in the form of the quartzites of Portland and Waterloo.

The outcrops in the town of Portland are several in number. The most southwesterly is an oval island lying mostly in the S. E. quarter of Sec. 33, and is entirely surrounded by lowland or marsh. The outcrop attains but a slight elevation, and its rounded contour shows abundant evidence of the glacial agencies that have swept over it. Not only striæ, but deep, broad furrows, show the direction of movement to have been S. 15° to 20° W. Bowlders appear in great force upon the protected side of the island and doubtless thickly underlie the deep morass in that direction, as they appear again upon the hills beyond. Directly to the east, in Sec. 34, there is a slight exposure near the base of a somewhat elevated north and south ridge, of which it doubtless forms the nucleus, if not the chief portion.

Less than 1 mile north of these outcrops the quartzite again discovers itself on the brow and west flank of the ridge facing Waterloo creek. There is no evidence that any later formation overlies the quartzite between

this and the two preceding outcrops, and so the three will be found mapped as constituting a single Archæan area. A short distance further to the north (N. W. quarter Sec. 27) the quartzite rises in the midst of a marsh-like lake, constituting Rocky Island. It may be characterized as a low dome covered with nunnumerous *roches moutonnées*.

About 2 miles southeast, at the foot of a hill, and on the edge of a marsh, occurs a low and limited outcrop (Sec. 35, S. E. quarter, and Sec. 36, S. W. quarter). One-half mile to the northeast, across a marsh, there occurs another exposure, similarly situated in a southern extremity of a north and south ridge, and about the same distance to the southwest still another one may be seen, the three lying nearly in a straight line and separated by marshes. They are regarded as being projecting knobs of a common area, and are so mapped. Between these and the three outcrops first mentioned, as also between both these and Rocky Island, later formations intervene, so that they must be regarded as forming three distinct, though closely associated, surface areas.

MINNESOTA.

[Compiled mainly from notes by Professor N. H. Winchell.]

CRYSTALLINE SILICEOUS ROCKS.

More than half of the state is underlaid by that general class of rocks—the crystalline—to which granite belongs, and consequently the state has almost every variety of crystalline rock. These rocks also exhibit all degrees of durability and value for building purposes. The granular crystalline rocks are generally very durable; and, whenever they are exposed above the drift, can be wrought with profit and with the most satisfactory results. While in the northern part of the state there are large exposures of very fine light-colored granites, beyond the limits of settlements and roads, and particularly at lake Saganaga, those in the valleys of the Mississippi and Minnesota rivers are of more special and immediate interest. These have been somewhat quarried, and their products as building materials can be seen in some of the principal buildings in various parts of the state, as well as in cities outside the state. The gray granite that is quarried at Sauk Rapids, and which generally is seen in Stearns county, consists largely of quartz embraced in a matrix of orthoclase, with but a small proportion of mica or chlorite. Hence it is hard and very durable. The dark mica is biotite, and there is but occasionally a grain of hornblende. This last sometimes prevails largely over all the other minerals in small areas or veins, making a very dark-colored and also generally a coarser-grained rock. There is also occasionally a grain of triclinic feldspar and of magnetite, and some minute crystals of pyrite. These minerals have a relative hardness when expressed on a scale of 10 as follows, 7 being the hardness of an ordinary knife-blade:

Quartz	7
Triclinic feldspar	6 to 7
Orthoclase	6 to 6½
Hornblende	5 to 6
Biotite	2½ to 3
Muscovite	2 to 2½
Chlorite	1 to 2

About one-half of the whole rock is made up of quartz, and two-thirds of the remainder of orthoclase. About one-half of the rest is triclinic feldspar, and the residue is divided between the other minerals, biotite predominating. It is plain to see that such an assemblage of minerals constitutes a very firm rock, and one that is rather hard to dress, but when once cut to form and placed in a building it will endure indefinitely. The biotite, muscovite, and chlorite serve to make the granites easy to cut and to quarry; and particularly when they lie in sheets or in indistinct belts through the rock, giving it a faintly striped aspect, constituting a gneiss, the rock can be got out easily in large, long slabs or blocks. When these are evenly scattered through the whole rock, the rock is simply softened, and in quarrying the fracture will have to be more completely guided by the plug and feather. For taking a polish the absence of these soft minerals enhances the value of the rock. The durability of the Sauk Rapids granite was tested at Washington under direction of the chief of engineers, and was found capable of sustaining a crushing pressure of from 15,000 to 17,000 pounds per square inch. A quarry at Sauk Rapids has been longest known of all the granite quarries in the state, but it is not now (1880) as vigorously operated as those at Watab or at East Saint Cloud. Blocks 12 by 3 by 1½ feet thick and 10 by 4½ feet by 1 foot thick have been quarried, and blocks as large as 26 by 22 by 5 feet thick might be moved if desired. The material is now used mainly for monuments, formerly also for building and for bridge construction. Among the principal structures in which this stone has been used are the capitol buildings at Des Moines, Iowa (trimmings); the city hall, Minneapolis; Nichols & Dean block, Saint Paul.

The color of this granite, being a neutral gray, makes it suitable for a wide range of architecture. Light-colored and reddish granites are found at Watab, a few miles north of Sauk Rapids, and also in a few places near Saint Cloud and Rockville.

At Watab there are three principal varieties of different textures and colors, each being quarried from a different opening, so that the stone in each quarry is uniform as to texture and color. The red is located to the north of the gray granite, and is separated from it by a distinct line, a change being abrupt (within 6 inches). Although the

quarry was opened some years ago, it was not operated during 1880. This stone is being used in the construction of the bridge over the Missouri river at Bismarck, and about 7,000 cubic yards will be used for this purpose. The following is a report on this stone, by Captain Edward Maguire, U. S. A., chief engineer, department of Dakota:

Two kinds of granite were used by the Northern Pacific Railroad Company in the masonry work on their bridge at Bismarck: first, a light-colored and reddish granite, found at Ward's, a few miles north of Sauk Rapids, Minnesota. The quality of this stone was good, but its use was abandoned on account of the cost of quarrying it. The bed is very much cut up by seams, and in order to obtain the requisite sized blocks it was necessary to quarry about ten to one. The largest blocks that have been quarried are 6 by 4 by 2 feet thick; some blocks 30 by 12 by 5 feet thick have been moved, but were cut up for transportation. The texture is rather coarse and moderately crystalline.

Captain Maguire reports an examination of gray granite from the Rock Island quarry, situated in a prairie about 4 miles from Saint Cloud, and there are at least 4 and probably 10 acres of this gray granite from which blocks of any size or shape may be quarried.

While the granites of Stearns county are massive or non-gneissic, those of the Minnesota valley are almost invariably of a laminated structure, and of a reddish color. One of the principal exceptions occurs in the large granite outcrop near the foot of Big Stone lake. The Minnesota Valley granites differ from the Saint Cloud granite, also, in being softer, on account of having less quartz and more of the cleavable minerals, orthoclase and mica. They are also easy to quarry, but they have not been much worked yet. Some of the recent cuts in the red granite near Montevideo, by the grading for the railroad, show a very superior variety of rather coarse grained red granite, which cannot fail ultimately to be in great demand. There are great stoneless tracts of prairie lying south and west of the upper Minnesota Valley region, and extend from near New Ulm to the foot of Big Stone lake.

The so-called granite of Duluth belongs to a very different class of rocks, and is more properly styled "gabbro", a new term derived from Italy, and applied to an igneous rock consisting of the triclinic feldspar, labradorite, augite, and a magnetic oxide of iron containing titanium. These minerals are all softer than quartz, which is wholly absent from the Duluth rock, but which makes up so large a part of the Saint Cloud granite. It is strange, therefore, that the Duluth rock should have been so generally regarded as harder than real granite, and particularly as harder than the Saint Cloud granite. The mineral augite, which makes up generally less than one-fourth of the whole, has a hardness of from 5 to 6 on the scale of 10, and labradorite is but little more. When this rock begins to decay, the augite changes first, making a greenish, soft mineral like chlorite, and this change sometimes is found to have gone on to a great depth in the rock without any change being seen in the other minerals. In such cases, while the rock is not much injured for building purposes, it is more easily quarried and dressed. While taken in a mass this Duluth rock may correctly be said to be softer than the Saint Cloud granite; it is tough and firm, being perfectly crystalline and compact. The magnetite in this rock sometimes becomes so abundant that it spoils it for building, and even becomes an iron ore, and has attracted attention as such. The iron ore reported some years ago at Duluth, at Herman, a few miles west of Duluth, and at Iron lake, north of Grand Marais, is all of this variety, and in some cases it is pure and valuable; but it is damaged by the presence of the titanium. The titanium is not so much a damage to the iron as an impediment in the reduction of the ore. At Duluth this rock has been used in some foundations, but the difficulty of dressing it, as well as of quarrying, has prevented its acceptance as a general building material. Its strength is about 17,000 pounds per square inch.

The gabbro quarry at Duluth, Saint Louis county, is from a mountain-like range extending northeast from Rice's point at Duluth. It is discussed in geological reports of Minnesota for 1879 and 1880, it being No. 1 of the *Minnesota Geological Survey* series. The rock is of the age called Cupriferous in Minnesota, the equivalent of the Potsdam in other portions of the country. Blocks of as large a size as could be handled might be quarried here. The mass of rock is but little jointed; its texture is a uniform crystalline, and it has been used thus far chiefly in trimmings for buildings and for rough walls at Duluth, and some for trimmings and steps at Saint Paul.

A trap from this formation has been quarried by the United States government to be used in the construction of breakwaters at Duluth. The stone is roughly and basaltically bedded, and it may be called imperfectly basaltic; its texture is uniformly crystalline; it is No. 53 of the *Minnesota Geological Survey*, report of 1880. It is a basaltified layer of igneous rock intercalated between sedimentary beds. There is an excavation made in trap-rock for the site of a new school-house in Duluth, and the stone is put in the foundation and basement of that building. It is seen in outcrop conspicuously in front of the engine-house in that city, and extends northeastwardly in the form of a low hill range or ridge; it seems to be that which forms the falls of Kiuichiguaguag creek, near Duluth; it is No. 43 of the *Minnesota Geological Survey*, report of 1880. This stone is massive, close, and fine in texture, sometimes finely porphyritic; the mass of rock is distantly jointed.

No. 42 of the reports of the *Minnesota Geological Survey* of 1880 is not quarried; it is so situated in many places near Duluth that it might be quarried with profit where a stone easier wrought than No. 1 of the series is desired. In the weather it has naturally assumed numerous conchoidal-fracture planes. These make it difficult to get blocks of a given size and shape, since the pieces break in dressing along the old fractures, which are not parallel nor perpendicular, but cross at acute angles in all directions, like some massive shale in disintegrating. This rock is believed to be derived from the red shale of the Cupriferous or Potsdam series by the semi-fusion incident

to the igneous ejections; other stages of crystallization, even to red granite and other less changed conditions as a perfect red shale, can be seen along the shore at points farther down the lake and at Duluth. Within the limits of Duluth it can be quarried as red granite; it is in the hill range on the slope facing the bay, and at the quarry at Rice's point is associated with No. 1.

In the hills back of Duluth it changes suddenly to a red granite, supposed to be derived from the fusion and metamorphism of the Fond du Lac red shales and sandstones when the igneous rock was poured out through and over them. These two kinds of rock (red syenite and gabbro) are closely intermixed in patches, sometimes of large area, and extend thus all the way to the northern boundary-line of the state, the red rock showing various stages of metamorphism and crystalline condition. The red granite in some places is very coarse grained and beautiful, something like Scotch granite, and in other places it is very fine grained and compact, as at Duluth. It contains quartz, generally in large quantity, red orthoclase, and green hornblende or chlorite.

At East Saint Cloud, Sherburne county, a massive Archæan granite is quarried for general building purposes and used chiefly at Saint Paul, Milwaukee, and Minneapolis. The trimmings of the United States custom-house at Saint Paul are of this material. There are three varieties, differing somewhat in texture and color. The one most used and highly prized is of a fine-grained uniform texture and gray color. It is often slightly gneissic or laminated in structure, and works more easily than the others; it is probably not so durable nor firm under pressure. The second variety is red, and contains a good deal of quartz, but takes a finer polish. It was not quarried during 1880 so much as in former years, chiefly because the plant of the establishment is situated some little distance from the favorable exposures, but there is abundant opportunity in the neighborhood for working this red granite. The other variety is not now quarried, but large quantities of it were formerly taken out and used chiefly as trimmings in the custom-house at Saint Paul, where, however, stone of both the other kinds is also to be seen. It has outwardly, and especially when chiseled for construction, as in the custom-house, very much the aspect of the gabbro quarried at Duluth, and might be mistaken for that stone on a casual examination. It has the reputation among the quarrymen of being very hard, and is said to require more frequent sharpening of the tools than either of the other varieties, which circumstance has prevented its extensive use.

The East Saint Cloud granite, when used for paving, is dressed roughly in blocks of about 10 by 3 by 5 inches deep. Blocks 50 by 12 by 6 feet thick have been moved; the size of blocks which may be quarried is only limited by the ability to handle; blocks 20 by 6 feet and as long as 60 feet may be quarried if desired.

There is a very firm syenitic granite near Morley, on the Northern Pacific railroad, which is similar in outward appearance to the Saint Cloud granite, and will furnish stone for a large tract of stoneless country west of that point, this being the most westerly outcrop of rock known on the line of that railroad within the state.

At Beaver Bay, Lake county, a red granitized shale of Cupriferous or Potsdam formation (metamorphic group, and is one of the conditions of the metamorphosed sedimentary rocks of the Cupriferous series) is somewhat quarried for dock construction. The ledge lies conveniently near the docks, in the construction of which this stone was used. The rock was taken out in the north side of the bluffs facing the bay. The material is rather fine in texture. The structure of the rock is somewhat basaltified, yet jointed transversely.

Four miles below Beaver Bay, on an island in lake Superior, a so-called red granite of the Cupriferous series is found, but has not as yet been quarried. It is No. 811 of the *Minnesota Geological Survey* reports. It is believed to be derived from some of the original sedimentary portions of the Cupriferous beds, and would make a very good building material if in the course of the settlement of the country it should become desired. The rock is uniformly crystalline in texture; at most points it is little jointed, but it is occasionally imperfectly basaltic.

There is a labradorite rock of the Cupriferous series exposed at the lake shore, 2½ or 3 miles east of Beaver Bay, which may be used for ornamental purposes as well as for general construction. The supply is abundant and easily accessible. The rock seems to graduate into the gabbro exposed at Rice's point. The texture of the stone is uniform and coarsely crystalline; it is bedded in some places and in others a solid mass.

At the lake shore, near the mouth of Baptism river, Lake county, there is a porphyritic felsite of the Cupriferous series; it is Nos. 138 and 139 of the Minnesota geological report for 1880. The stone is porphyritic, with quartz and perhaps adularia, and it is indistinctly laminated and basaltic in structure. The rock is also exposed 2 miles west of the great palisades, on the north shore of lake Superior, Lake county; it may possibly be used for ornamental purposes, and it illustrates the gradual change from the red shales of the sedimentary beds of the Cupriferous to crystalline rock. (See proceedings of the American Association for the Advancement of Science for 1880–'81.) In this locality there is also a metamorphosed shale (with adularia) of the Cupriferous series; it is No. 140 of the *Minnesota Geological Survey*. Specimens of the stone in the National Museum are a brick-red in color; it is usually banded and porphyritic, with quartz and translucent grains that seem to be adularia.

On Encampment island, Lake county, a hyperyte rock of the igneous group of the Cupriferous series is found; it has not been quarried for building purposes, but is interesting from a scientific point of view. In texture it is uniform and coarsely crystalline, and is irregularly jointed and bedded. On the shore of lake Superior, at Two Harbor bay, in Lake county, there is a dark, heavy, uniformly fine-grained rock, probably of the sedimentary group of the Cupriferous. It has not yet been quarried, but has a scientific interest in connection with the investigation of the crystalline rocks of this formation, as its outward characters have not been sufficiently distinct to indicate its

affinities so as to warrant its being classed in either the igneous or metamorphic group of the Cupriferous. In the Report of the *Minnesota Geological Survey* for 1880 it is placed in the sedimentary rocks (metamorphosed), but this point is not well established. With it many comparisons have been made, and references in field-books, whenever it has been seen to occur, or where a rock like it has been met with, making it a sort of datum for the mapping geographically of rocks in other places.

A trap of the igneous group of the Cupriferous is quarried at Taylor's Falls, Chisago county, and used in the construction of foundations and rough walls at Taylor's Falls. The walls of several business blocks at this place are constructed of this stone. The color is dark, almost black, and as to the texture it seems to be made of pyroxene crystals embracing the other minerals, these causing a spotted exterior; otherwise the texture is uniform. This rock, from its proximity to Minneapolis and Saint Paul, is of economic importance because of its adaptability for paving blocks, for which purpose it would supply a most durable material. It may be described as tough rather than hard. It is the most southerly known exposure of the Cupriferous in the state, though in Wisconsin a similar rock outcrops a few miles farther south, near the Saint Croix river. Some interesting copper mining has been excited at this point by the discovery of the native copper in the rock and along some of the ravines. It is No. 820 of the *Minnesota Geological Survey*; the rock seems to have the characteristics ascribed to melaphyre by Pumpelly.

SANDSTONES.

The red quartzite at New Ulm, which also is seen in Cottonwood, Watonwan, Rock, and Pipe Stone counties, is sparingly used for a building stone at points contiguous, and one or two car-loads are known to have been shipped to Minneapolis. It is the hardest stone in the state, or in the United States, probably, that can be said to have been used for building. It consists almost wholly of quartz, the red color being due to iron oxide, which is disseminated among the grains, but does not enter them. As a layer embraced in this rock the material known as "pipestone" or catlinite is found in Pipe Stone county and other places in southwestern Minnesota. This rock it is very difficult and costly to dress into dimension blocks, but it is indestructible when once placed in a wall.

There is a quarry of the red quartzite in Courtland township, Nicollet county, near New Ulm, operated for ordinary building purposes and bridge construction, used at New Ulm and surrounding country. It was used in the construction of Sommer's block and the residence of Mr. Frank Erd, at New Ulm. The stone varies somewhat as to texture, some being loose-grained and sandy, and some firm, hard, and uniform. It is evenly-bedded in courses varying from half an inch to 4 feet in thickness; the joints and water-cracks are not distinct, but rather frequent. There is but little systematic quarrying done at this place; quarries are contiguous, and exhibit the same kind of rock. Some of the beds are shaly, and the dip about 15° toward the north-northwest. As compared with rocks at Sioux Falls, in Dakota, the opportunities for quarrying are greater here and the stone is much more easily wrought, owing to the fact that the beds are finer and softer, though it is probable that if it were to be deeply excavated it would be found to be firm and of a purplish color within; but at Sioux Falls a greater area of stoneless country surrounding the quarry will create a greater demand than ever will be felt at New Ulm.

Next in ascending order, as building materials come the sandstones proper, if we omit the black argillyte or roofing slates and their associates seen at Thompson, which will be treated under "Roofing slate". The red sandstones at Fond du Lac are probably the most valuable deposit, taken on all accounts, that the state possesses as a building stone of that kind. They are of the same formation as the New Ulm quartzite, but were less hardened at the time of their upheaval. They lie tilted toward the south or southeast, and are associated with and overlie a vast thickness of soft red shale, which passes sometimes to a shaly red conglomerate, the same that in other places about lake Superior is in contact with the igneous rocks, and becomes copper-bearing. This red sandstone is well known in Milwaukee, Chicago, and Detroit. The quarries in it farther east furnished the red sand-rock used in the Milwaukee court-house, and a great many brownstone fronts in that city and in Chicago were obtained from it. It was formerly quarried on Isle Royale, and sold in Detroit as "Isle Royale brownstone". While it consists almost entirely of quartz, the grains are not so firmly cemented or united as to render it objectionably hard. Its grain, color, and texture vary slightly. On Isle Royale, when quarried, it is fine-grained and rather brittle, being more highly metamorphosed than at Fond du Lac. At some points it has a mottling of red and gray, or even of green, as at Sault Ste. Marie, at the eastern end of lake Superior, where the ship-canal is cut in it and largely built of it. In some places it is so loosely cemented as to crumble and to be rendered useless for building, and in others it contains rounded quartz-pebbles of a nearly white color, or becomes wholly conglomeratic. At Fond du Lac some of all these features can be seen, but there is still at that place a great abundance of fine stone of the best quality. This great formation forms the southern rock barrier of lake Superior, almost without interruption, from Duluth to Sault Ste. Marie, but it is not always of so dark a color as it is at Fond du Lac. The famed "pictured rocks" of the south shore are formed of it, and the Apostle islands are caused by remnants of it that withstood the erosion of the glacial forces. Its strength, as tested at Washington, proved to be from 4,000 to 5,000 pounds per square inch. Several business blocks have been made from it in Duluth, and the new Westminster church at Minneapolis is being constructed of it. This formation is seen not only at Fond du Lac, but (probably) at Pokegama falls, on the Upper Mississippi, and in the base of the bluffs at Winona, but the most favorable and promising points for quarrying it are at Fond du Lac.

The principal quarry at Fond du Lac has been mainly engaged in getting out and shipping stone in the rough, but little being dressed at the quarry. The rock has in some of its heavy bedding stripes of light sand rock, and light spots in some of the brown. Sometimes scattered quartz pebbles are seen in the light rock of the size of a pea, or even a hen's egg, but not much of it is conglomeratic. Lumps of red shale from 2 to 5 inches in diameter occur in belts coincident with the direction of the bedding. The bedding is even, in courses varying from 4 inches to 2 feet in thickness; the joints are distinct. The stone is used for general building purposes, chiefly at Minneapolis, Saint Paul, Brainerd, Duluth, and Fargo, Dakota, and Superior, Wisconsin. Among the buildings in the construction of which this stone was used are the Clark & Hunter block of Duluth, the Westminster Presbyterian church at Minneapolis, and some of the railroad buildings at Brainerd. There is a quarry on Missouri creek near Fond du Lac, the product of which is wholly shipped to Winnipeg for use by a contracting builder of that city. The Manitoba college is trimmed with stone from this latter quarry.

The freestone at Hinckley is probably not of the same formation, but pertains to a higher horizon—the Saint Croix. It is exposed on the banks of the stream passing through the village and at points farther down. As a building stone it is considerably lighter colored, or more nearly that of the Kasota stone, and more easily wrought than the Fond du Lac stone. It is in even, heavy beds, and can be easily got out. It is as firm and as desirable for all purposes of architecture to which it is adapted as the Cleveland freestone which is so largely used. It can be dressed more cheaply than the Fond du Lac stone and can be cut into ornamental forms for capping or for columns. Its compressive strength has not been tested yet.

The stone from this quarry is evenly bedded in courses varying from 6 to 18 inches thick; there are but few joints. The Saint Paul and Duluth Railroad Company operates the principal quarry at Hinckley, Pine county, for bridge construction, and the stone has lately been put into the foundations for the high bridges and trestle work on that railroad along the dalles of the Saint Louis river. It is the only rock known between White Bear lake and the slate region of Thompson, which begins near Goose Lake station.

At Dresbach, on the Mississippi river and the Chicago, Milwaukee, and Saint Paul railroad, in Winona county, sand-rock of the Saint Croix, which is the lowest sand rock in the geological scale of Minnesota, is occasionally quarried for ordinary building purposes and shipped to Minneapolis and Saint Paul. The stone promises considerable usefulness in the future, though as yet is but little quarried. The rock has been quarried to a limited extent also at Dakota, 2 miles north of Dresbach, and much attention has been attracted to the material at both these places, as it nearly resembles the Berea sandstone of Ohio, which is now largely used in first-class buildings in Saint Paul and Minneapolis, it being transported there by rail at considerable expense. The development of this industry in Minnesota, so far as Dresbach and Dakota are concerned, is due to the direct and immediate efforts and recommendations of the geological survey of the state in calling attention to it during 1880. There is an unlimited supply of this stone in the bluffs of the Mississippi river, but its best color is found only near the level of the water of the river. The stone is of a fine texture, and varies from a light gray to buff in color, some of it showing even and distinct stratification, and some being massive; it is evenly and horizontally bedded in courses from 3 inches to 8 feet thick. Blocks 8 by 4 by 4 feet have been quarried; and blocks as large as 20 by 8 by 6 feet, or as large as could be conveniently handled, might be quarried.

The other sandstones of nearly the same geological horizon are not very good for building, being too friable. They are exposed in the bluffs of the Upper Mississippi below Hastings, and of the Saint Croix below and above Taylor's Falls, where they have been put into one or two business blocks. They are of rather coarse grain and friable on first quarrying, but the weather operates to harden them somewhat in the course of a few months. When they are finer, and mingled with an aluminous sediment, they are also somewhat magnesian. They are then fit for rough walls, but for first class architecture they cannot be used, owing to the thinness of the layer and the general incoherency of the grain. Still in some towns this kind of stone is employed exclusively for the general home demand, as at Hokah and at Lake City.

The Jordan sandstone of the geological horizon of that name in the Lower Minnesota valley is very much like that at Taylor's Falls, but is in a much higher geological horizon. It has been used considerably at Jordan, and serves a good purpose for general building, but it cannot be recommended for first-class structures. It is of a light color, but stained and clouded, or striped by a yellowish or rusty iron cement. It is likely that the darker-colored beds of this stone will be found most durable. This rock appears in the Minnesota valley, forming islands and rapids near Carver. If it were to be wrought along the Minnesota river, where it has been for a long time subject to the rusting and cementing action of the waters of the river at periods of flood, it would be found much harder and more valuable. The bedding is even, and in courses varying from 2 inches to 2 feet in thickness, jointing irregular, the texture fine, sometimes friable, and there are signs of irregular stratification. There are two principal varieties in the quarry; that from the bottom is of light gray or bluish color; that from the uppermost 16 feet of the ledge is the stone which has been hitherto used exclusively in building. The gray is very similar in appearance to the Berea, Ohio, sandstone. Among the buildings in the construction of which this stone has been used are the Foss & Wells flouring-mills, at Jordan, and the City mills and the American house (first story), at the same place.

Ordinarily the Saint Peter formation is very friable, and particularly where it is freshly exposed, or is being continually reduced by the action of winds or by running water. But when the river water occasionally or

periodically overflows it, the repeated evaporation of the water leaves a deposit of iron-rust, which on entering among the loose grains of the rock soon so firmly cements them, especially on being thoroughly dried, as to make a useful building stone. Such a process goes on in all low grounds where water evaporates without free escape, and generally causes a rustiness on the mud or on the dead twigs or roots of the place, or even goes so far as to form a bog iron ore. If a rock be exposed there it becomes more or less rusted, and if before incoherent it becomes firm. Although stone quarried from this formation has been put into the piers of the bridge at Fort Snelling in large blocks, it can hardly be said to constitute a reliable supply of good stone for the cities of Saint Paul and Minneapolis. When evenly and thoroughly cemented by the iron-rust it will form a durable rock, but its liability to inequalities in the hardness of the mass, to variations of color, and to the exhaustion of the supply will operate against its extensive use.

At Mendota, Dakota county, sandstone rock of the Saint Peter subdivision of the Lower Silurian is quarried for bridge construction on the Chicago, Milwaukee, and Saint Paul railroad. The piers of the bridge over the Mississippi river at Fort Snelling are built of this stone. This stone, which serves well for heavy masonry, and could be cut for ornamental work in structures, shows the effect of the waters of the Mississippi river in hardening the very friable white sand-rock, known as the Saint Peter sandstone. The outcrop in which the quarry is situated is in the bottom land of the river and rises but a few feet above low water. It is annually overflowed and has been for an unknown period evidently, at least since the glacial epoch, and it is to this fact that the cementation of the siliceous grains is due, the evaporation of the water as summer advances leaving a sort of iron cement. It is also probable that the cement is partly siliceous, since the waters of the river are slightly alkaline, and thus might dissolve some of the silica of the rock, depositing it again as a cement. No other such effect on the Saint Peter formation is known but in the valley of the Minnesota river. Above this place, the Shakopee formation is thus affected at Kasota, the Jordan at Van Osser's creek, near Louisville, and the Saint Lawrence at Jessen Land; in all cases the change of character being due to the interpenetration of iron oxide on the evaporation of the water of the river.

The stone used at and below Austin, taken from the low banks of the Cedar river, seems to belong to the Upper Devonian. It is believed to lie conformably over the Devonian limestones that are seen in outcrop farther down the river, a few miles south of the state line in Iowa. The stone itself in its natural color is of a light blue, and that color shows on most of the quarried blocks about the heart of the bedding, and on deep quarrying it would doubtless show only a blue color. Yet the stone as now used is very generally of a buff color to the depth of from half an inch to 3 inches, depending on the amount of weathering and oxidation. The thinner beds are altogether changed to that color. The texture of the stone is close, and the grain is homogeneous. Some large slabs and blocks are sawed for bases to tombstones, and worked down to a very smooth surface. It is more safely sawed to any desired dimension than cut or broken, yet it is not in the least crystalline. Its aspect at a distance is that of a fine-grained sandstone, yet it contains no apparent grit. It is so soft that it can be cut without difficulty, appearing much like an unusually indurated blue shale, but it hardens in use and serves a useful purpose in common buildings, but cannot be depended on for first-class structures. Its argillaceous composition will ultimately cause it to crumble, especially if it be subjected to frequent changes of moisture and dryness.

At several points in the banks of the Minnesota river between New Ulm and Mankato a hard, siliceous sandstone of Cretaceous age is exposed, which has supplied some very good building material. The layers are about 4 inches in thickness, and are tough and firm. They are associated with alternating layers of a friable sandstone, which aids in their extraction. These beds are sometimes so coarse as to justify their being designated as conglomeratic. The stone is very durable as a building material, but the toughness and hardness of the texture and the thinness of the beds, make it more suitable for flagging than for building. It is typically exposed on the land of William Fritz, Sec. 16, T. 109, R. 29, in Nicollet county and other places near.

LIMESTONES.

The lowest limestones in the geological scale are those seen in the bluffs of the Mississippi river and in the Saint Croix valley. They generally form the tops of the bluffs, and cause the precipitous portions, the sloping talus being taken up with one or more of the sandstones above mentioned. These limestone beds present a varied lithology, and cause some very interesting topographical features. As a building stone they are wrought at all points where there is a demand (except Lake city), between Stillwater and Winona, along the Mississippi valley on the Minnesota side, and also at several places farther west, as at Caledonia, in Houston county, Lanesborough and Rushford, in Fillmore county, and at points in Winona county. The material they supply is in general a magnesian limestone of a light buff color, a firm but sometimes vesicular or porous texture, and often having a considerable proportion of quartz. An analysis of a sample from Sugar Loaf, Winona, gave the following result:

	Per cent.
Insoluble (mainly quartz)	24.24
Ferric and aluminic oxides	3.32
Calcium sulphate	4.32
Calcium carbonate	47.11
Magnesium carbonate	20.07
Total	99.72

Showing that nearly one fourth of the whole consists of quartz. In other places would be found less quartz; and this is particularly the case at Frontenac, where the rock is so even-grained and so free from quartz that it is sawed by machinery into such slabs or blocks as are wanted. The quarries at Winona and Red Wing are in beds of this stone that are quite similar as to texture, being open and loose, or having small scattered cavities. In these cavities are sometimes linings of drusy quartz crystals. In other beds this quartz is gathered instead into nodules of chert or flint, which, although having a white exterior, are hard, and often gray within. This is the condition of the quartz in the stone at Frontenac, but these flint lumps are not common there. In other places whole beds are cherty and worthless for a building stone. This formation, which probably at the present time furnishes more stone than any other in the state, is destined to be still further used for the same purpose, as it is most favorably situated at its exposures both for excavation and for shipment and transportation, and supplies one of the best materials for all purposes of architecture. It varies from a light buff to a light drab color. When placed in a structure it has a lively and cheerful expression. At Frontenac it is cut into ornamental forms with comparative ease, and the same kind of beds as those at that place are found throughout the southeastern part of Goodhue county and the northern portion, at least, of Wabasha. It is but slightly changed after many years exposure to atmospheric influences; indeed, it has not been in use long enough yet in the state to show any change whatever by lapse of time, although it is in some of the oldest buildings of the state. The homogeneity of its composition and texture, as at Frontenac, and the regularity and thickness of its bedding, are qualities that enable it to supply slabs and blocks of any desired dimensions. Its resistance to pressure, amounting to 5,000 to 7,000 pounds per square inch, is sufficient to warrant its use in all ordinary structures, while for door moldings and caps, for sills and water-tables, and for all trimmings to brick structures, it is unsurpassed.

The limestone of the Saint Lawrence horizon, the lower portion of the great magnesian limestone of the west, in the vicinity of Stillwater lake, is often somewhat siliceous, and the determinations made at the National Museum for this report show it to be properly sometimes a dolomite and sometimes a siliceous dolomite. A chemical analysis of the samples of the stone usually show a high percentage of magnesia, considerable iron, and siliceous matter. At a quarry of this limestone at Stillwater, on lake Saint Croix, and on the Saint Paul and Duluth railroad, the ledge is about 45 feet thick, and extends still farther below. It alternates in bands of compact and of vesicular rock from 3 to 6 feet each, and there is about an equal amount of each kind, all lying in horizontal courses. The coarse and vesicular dolomite is used for the heaviest masonry, such as bridge construction; it is in beds of from 18 to 30 inches thick, and is more firm and durable than either of the other varieties. One variety is called "sand-rock" by the quarrymen, though plainly containing very little, if any, quartz sand, and has a uniform and granular texture. The other principal variety is most useful for general purposes; it is especially sought for and adapted to use for sills, water-tables, and caps, making a stone which is fine and uniform in texture, and of uniformly light buff color. It yields a good surface under the hammer and chisel, and is employed for bases and tombstones; it is also used for ashlar, pilasters, and copings. The use of this stone thus far has been only local, and the following are some of the buildings in the construction of which it has been employed: The state prison, public school-houses, one Catholic church, store building of Mr. Isaac Staples, Universalist church, and the Fayette-Marsh block, all in Stillwater.

The Saint Lawrence limestone is quarried at Stockton, Winona county, for bridge construction and foundations, and employed in the railroad work along the Winona and Saint Peter railroad and in the towns on that road. The stone was used in the construction of the railroad round-house at Winona. In texture it is generally uniform, but sometimes vesicular, cherty, and geodic; in color it is buff; it is a dolomite containing a small percentage of iron. The stone is evenly and horizontally bedded in courses usually from 9 to 25 inches. There is a coarse concretionary (apparently brecciated) condition sometimes seen in this formation from 25 to 100 feet in thickness, which has to be entirely thrown away or used as filling by the railroad. A concretionary condition occurs in isolated masses and nodules, and does not extend far horizontally; at least it is not always present at any given horizon. The quarry is operated by the Chicago and Northwestern railroad, and most of the best stone is used in bridge and other construction. The Saint Lawrence is quarried also at Winona for general building purposes and flagging for local use; some of it is burned for lime and shipped to Minneapolis and Saint Paul. The location of the principal quarry is on an eminence known as Sugar Loaf hill. The stone has been used in the construction of a Congregational church, an Episcopal church, and the jail at Winona. It is usually fine and uniform in texture, but some of it is porous and contains quartz lumps. The color is usually buff; it is evenly and horizontally bedded in courses from 4 inches to 3 feet in thickness; there are signs of irregular stratification. Blocks 8 by 6 by 2½ feet thick have been quarried, and blocks of any size that can be handled may be quarried. The perpendicular joints are usually from 10 to 20 feet apart. The magnesian limestones of Minnesota are generally buff in color—at least the dolomites are—the only variation from buff being in some of the aluminous parts of the Trenton, when the term "dirty drab" might be used, perhaps.

The Saint Lawrence limestone quarried at Red Wing, Goodhue county, is used locally for general building purposes and for quicklime. It was employed in the construction of Christ church, the Red Wing and Diamond flouring-mills, the first stories of the Saint James hotel, and the residence of Dr. A. B. Hawley, all at Red Wing. It is a dolomite, fine in texture; some is vesicular and some compact, and the color varies from buff to light buff. It is

evenly and horizontally bedded in courses varying from 4 inches to 3 feet. Blocks 8 by 6 by 2½ feet in thickness have been quarried, and blocks of any size that can conveniently be handled may be quarried. The quarries at Red Wing do not differ much in the manner and kind of stratification, or in the quality of stone produced, from those at Stillwater.

At Frontenac, in Goodhue county, this formation is quarried for general building purposes, and used to some extent also for bases and tombstones. It was used in the construction of Barney's block, in Saint Paul. It is here also a dolomite of medium fine and very vesicular texture, buff in color, and evenly and horizontally bedded in layers often as thick as 5½ feet; it is jointed at irregular intervals. The dimensions of the largest block that has been quarried are 11 by 7 by 5½ feet, weighing 18 tons; this is about as large as can be obtained from the quarry. Saws and rubbing beds are used in dressing this stone at the quarry. This stone is considered one of the best in the state; it is seen in some large first-class buildings in both Minneapolis and Saint Paul, and the front of a large block in Minneapolis is being constructed of it by Mr. H. D. Wood.

That limestone formation (Shakopee) which is wrought at Mankato, Ottawa, Kasota, Shakopee, and Saint Peter lies about 100 feet higher in the geological scale than the last mentioned, but it is in nearly all places where wrought of nearly the same character and as useful for all purposes, though it does not present the evenness of texture and freedom from quartz seen in the Frontenac stone. At Kasota the river has at some early time stained it in the same way that it has the Saint Peter sandstone, near Mendota, giving it a rusty pink color, or a fawn color, as described by Featherstonhaugh, and at the same time greater tenacity and endurance under pressure—10,000 pounds per square inch. For its beauty, its regularity of bedding—which is sometimes nearly 2 feet in thickness—and its homogeneous texture, which renders it easy to shape into all forms, it is adapted to ornamental work as well as heavy masonry. It is cut, as at Mankato, into posts, sills, caps, and water-tables. For its adaptability to all uses it is worthy of being ranked with the Waverly sandstone, which is beginning to be imported into Minneapolis and Saint Paul from Ohio, and it is more enduring even than that under the action of atmospheric changes, owing to the more general and abundant dissemination of the calcareous cement, while its variegated coloring and its more lively expression make it preferable in many kinds of work. It is used in the State Lunatic Asylum building at Saint Peter. The Episcopal church and the old asylum building are also constructed from it. The Baptist church in Saint Paul is built of the Kasota stone. In old structures where it has been exposed for a number of years to the disintegrating action of the elements it shows as hard and sound as ever. It even becomes harder at first on exposure as the quarry water dries out.

The Shakopee, the upper member of the Lower Magnesian, is quarried at Kasota, Le Sueur county, for general purposes of construction, and especially for bridges, flagging, and tombstones. It is used throughout Minnesota, and in Eau Claire, Madison, and Hudson, Wisconsin; Le Mars, Sioux City, and Muscatine, Iowa; Sioux Falls, Dakota, and Winnipeg, in Manitoba. The following are some of the principal buildings in the construction of which it has been used: In the Insane Asylum at Saint Peter; trimmings in Saint Mary's church, Minneapolis; Plymouth church, Minneapolis, and Gilfillan's and Odd Fellows' blocks, in Saint Paul. The stone is a dolomite, ferruginous, and contains considerable siliceous matter. Specimens of the stone at the National Museum are dendritic. The stone at Kasota is all, or nearly all, stained with iron having a faintly-pinkish color, although originally buff. This stain comes from the flooding of the Minnesota river at early (glacial) times. The stone is subcrystalline and vesicular, with signs of irregular stratification, and is evenly and horizontally bedded in courses from 3 to 4 feet in thickness. Blocks 10 by 11 feet by 1 foot thick have been quarried, and blocks of as large size as could be conveniently handled may be quarried. Around the joints there is a recent penetration of iron and carbonaceous stain, sometimes 6 or 8 inches in the joints, having a wavy outline, according to the rate and ease of penetration by infiltrating water. This is usually cut away as waste in dressing blocks of the stone. Much of the stone at Kasota and some of the equivalent beds at Mankato have a color (designated by Featherstonhaugh as "fawn-color", not common to building stone. It is an accidental quality due to the more free penetration or chemical retention of the iron of atmospheric ferrated waters. Wherever the stone of the Shakopee formation is found so situated as to have been covered by the Minnesota river in its flood stages, or in the floods of the glacial epoch, it is uniformly so colored. In none of its layers, when found in higher land in the interior of the state, is this color found, but it has usually the buff color of the weathered siliceous limestones (non-argillaceous). The highest-priced stone of the Kasota quarries is that which is most colored by the presence of iron, being faintly reddish or pink.

Near Mankato, Blue Earth county, the Shakopee limestone is quarried for railroad bridge construction and for general building purposes, and extensively used along the line of the Chicago, Saint Paul, Minneapolis, and Omaha railroad, the Winona and Saint Peter railroad, and the Chicago, Milwaukee, and Saint Paul railroad; in western and southern Minnesota; Eau Claire, Wisconsin; Sioux Falls, Dakota; Le Mars and Sioux City, Iowa; and the following are some of the buildings in the construction of which it has been used: The trimmings of the public-school buildings at Sioux Falls and Albert Lea, Minnesota; the jail at Blue Earth; the state normal school and other schools at Mankato. The stone is here also a dolomite, containing some siliceous matter, usually ferruginous; buff in color, subcrystalline, sometimes fine, close-grained, and sometimes open and vesicular, with cavities of half

an inch or less in diameter; signs of irregular stratification, evenly and horizontally bedded in layers often 6 feet in thickness; it is irregularly jointed, and blocks 8 by 4 feet by 18 inches have been quarried, and blocks 20 by 10 by 6 feet might be quarried. All the quarries in the vicinity of Mankato are in the same beds, and very nearly the same details of stratification are present. There is a bed of shale connected with the rock at Mankato which in some particulars resembles Decorah shale, but is more calcareous, and is possibly available for a cement. The light blue color which appears in the deep portions of some of the quarries indicates the original color of all the rock; on further quarrying this blue color will probably increase in amount. The Galena limestone (at first a light buff stone) at Mantorville, in Dodge county, shows the same change in the deeper layers. In the quarry of the Winona and Saint Peter railroad, near Mankato, for quarrying convenience the layers are designated as follows, from the top downward:

1st. White ledge, very fine-grained stone.
2d. Red ledge, harder and pinkish.
3d. Gray ledge, coarse-looking stone.
4th. Soft ledge, will not stand frost.
5th. Bridge stone, coarse in texture.

The Trenton limestone, which is largely used at Minneapolis, Saint Paul, Northfield, Faribault, and Chatfield, and was formerly quarried at Fountain for shipment to points farther west on the Southern Minnesota railroad, is a bluish, rather dark colored stone, that varies in value very much at different places between Minneapolis and the southern part of the state. At points toward the north, nearer the old shore line of the Paleozoic ocean, much aluminous shale was deposited, even in those comparatively quiet times when marine animals flourished and on their death supplied a considerable calcareous sediment. Farther south the quiet, lime producing epochs were less mixed with aluminous sediment, and were separated more distinctly by periods of agitation when large amounts of shale were deposited. Hence in this formation at Minneapolis and Saint Paul the aluminous shaly ingredient is distributed through the calcareous, and also constitutes heavy beds of itself, while at Northfield the calcareous layers are pure; at Fountain they are almost free from alumina and sand, and at the same time in passing toward the south the purely aluminous beds become less frequent as the calcareous become more numerous. The cities of Minneapolis and Saint Paul have to depend very largely on the Trenton limestone for building material or to import from other places. The stone itself has an attractive and substantial aspect when dressed under the hammer, the variegations due to the alternating shaly and limy parts giving the face a clouded appearance as of gray marble, without being susceptible of a uniform polish. Where protected from the weather the shale will endure and act as a strong filling for the frame work of calcareous matter for a long time; but under the vicissitudes of moisture and dryness, and of freezing and thawing, it begins to crumble out in a few years. This result is visible in some of the older buildings, in both Saint Paul and Minneapolis, and has provoked a very general inquiry for some suitable substitute in those cities. The natural color of the stone on deep quarrying is blue, but it is often faded to an ashen drab to the depth of several feet, depending on the ease with which water and air find access within. The porous layers are apt to be most faded. The long-weathered surface is of a light buff color, or if iron be present in dripping water or contained in the stone as pyrites, so situated as to be oxidized, the color is sensibly deepened to a rusty yellow, and at the same time the stone is rendered more enduring on account of the irony cement. This is noticeable at Minneapolis and at Saint Paul, where the old river bluffs, formed before the last glacial epoch, have endured the exposure of a much longer period than the river bluffs between Fort Snelling and Minneapolis that have been formed by the recession of the falls since the last glaciation. The shaly portions in particular, where closely mingled with the calcareous, are so stained and hardened that the rock seems almost another formation. It becomes separated into layers 2 or 3 inches thick. Some of the first large buildings erected in Saint Paul were made largely or wholly from such iron-stained and weathered parts of this formation, and, although they do not present that uniformity of color and appearance of solidity and strength that the dark blue stone lately quarried gives to a building, the stone itself has withstood the climate and storms of this latitude more successfully than later buildings constructed wholly of the blue-stone. Toward the southern portion of the state this changed condition is not so noticeable, indeed it is not so possible. The beds are more compact and calcareous, and the effect of the elements is more superficial.

In the vicinity of Saint Paul the rock is a slightly-magnesian limestone, containing protoxide of iron. The texture is fine and semi-crystalline, usually showing signs of regular stratification, evenly and horizontally bedded in courses from 3 to 24 inches in thickness, joints 10 to 30 feet apart; blocks 6 by 2 feet by 1 foot have been quarried, and blocks 10 by 5 by 2 feet may be quarried. Saint Paul and vicinity is the only market, and the following are some of the principal buildings in the construction of which the stone has been used: The Fire and Marine Insurance building, the cathedral, the McQuillan block, the German Catholic church, the custom-house, and most of the stone buildings in Saint Paul.

In the immediate vicinity of Minneapolis the stone contains varying amounts of magnesia, ordinarily hardly sufficient to be called a magnesian limestone. The upper layers in nearly all of the quarries are made up of a siliceous dolomite.

The lime, slightly-magnesian limestone, however, preponderates at all the quarries, and silica and protoxide of iron are nearly always present in greater or less quantity. The following is a full section of the Trenton, as exposed at the Minneapolis quarries, given in descending order:

1. Dolomite, somewhat argillaceous, making a durable building stone, but generally not regarded as highly as the rock of No. 5; it contains numerous casts of fossils; thickness, 8 feet.

2. Similar to No. 1, or gradually becoming more impure with shale; thickness, 2 feet.

3. Calcareous green shale, mainly in one bed or layer; thickness, 4 feet 8 inches.

4. The last passing gradually into a calcareous shale resembling the well-known building rock of this vicinity, sometimes used for rough walls, distinctly set off from the next below; thickness, 2 feet 4 inches.

5. The regular building stone of Minneapolis. The shale which impairs this stone is intimately disseminated through the calcareous layers without showing regular lamination, yet causing a mottled or blotched exterior on being dressed; the fossil remains are usually comminuted; thickness, from 10 to 14 feet.

6. A vesicular, less argillaceous, but magnesian and rather softer rock lying near the bottom of the blue limestone and generally not distinguished from it; thickness, 18 to 24 inches.

7. Blue shale, worthless for building; thickness, 2 feet.

As to the texture of the Minneapolis stone it is generally fine and compact, seldom vesicular, and often interlaminated with shaly belts. At some places it separates into lamina of from 1 inch to 2 inches on weathering; some of it is mottled with argillaceous spots, but is otherwise compact, though showing fragmentary fossils. The color of the stone most used at Minneapolis for construction is a light blue, and until recently it was used exclusively, but at present building stones from Ohio, Iowa, and Illinois are being introduced. Some of the building stones from other parts of the state are also being used in the city, particularly that from Frontenac and from Kasota. The Trenton at Minneapolis and Saint Paul splits under the weather along the dark argillaceous belts that pervade it, and for that reason is not now regarded as a first-class building stone. The better rubble from the upper layers of the Minneapolis quarries really embraces the best rock for dimension work, and as to quality it is as durable a rock as the highest priced; it is sold cheaper because of irregular shape in fracture, rendering it unfit for range work. However, the quarries in the central and northern part of the city do not have this rubble, nor the "soap rock", which is sold for poor rubble, that layer having been denuded by the glacial and drainage forces so as to leave only the regular "quarry rock", which is No. 5 of the section before given of the Trenton at Minneapolis. The lowest layers in all the Minneapolis quarries show some variation in the composition and texture.

The following is an analysis of the dolomitic white limestone at the Baxter quarry:

	Per cent
Carbonate of lime	55.533
Carbonate of magnesia	26.092
Iron and alumina	3.075
Insolubles	16.220

The blue limestone which prevails throughout this section is present in the same quarry. While this formation as a building material at its northern outcrops at Saint Paul and Minneapolis is rather inferior, at its southern exposures it furnishes a dark blue stone of excellent quality. Nothing can be more suitable for heavy walls, and especially for foundations below the water-table, and for all gothic structures, than the blue limestone taken from the formation at Fountain, or at some of the quarries at Faribault.

At Cannon City, near Faribault, Rice county, the Trenton limestone is a calcareous dolomite, containing protoxide of iron and silica; color, bluish-drab; massive, uniform, fine, and fossiliferous in texture; evenly and horizontally bedded in courses varying from 4 inches to 3 feet in thickness. Blocks 12 by 4 feet by 10 inches thick have been quarried, and blocks 20 by 3 feet by 15 inches thick may be quarried if desired. It is perpendicularly jointed at intervals. The material is used for general building purposes sometimes, and formerly for table-tops and work of that character. The market is at Faribault and within a radius of 20 miles of that place, where it was used in the construction of the Deaf Mute Asylum building, Shattuck School building, Episcopal church, and the public-school buildings.

The stone from the Faribault quarries is in the same stratigraphical horizon as that in the quarries at Minneapolis and Saint Paul. A comparison shows that the siliceous and the argillaceous impurities seen at the first-named place have greatly diminished in passing from north to south. There is a shale bed underlying the building-stone layers and separating them from the underlying Saint Peter sand-rock. The beds themselves are sometimes a foot thick, but are more generally from 6 to 8 inches in thickness. On deep quarrying they combine into heavier layers.

At Minneapolis, and to some extent also at Saint Paul, there is a very different sort of stone in the Trenton limestone formation overlying the beds that are wrought, which is more enduring than the regular building stone. This does not appear in the quarries near the falls, but is seen in those near the university, where the formation has not been so much eroded. This rock is generally rejected by builders, as already stated, and is confounded with the worthless shale that separates it from the regular building-stone layers. It is an impure limestone, containing a large per cent. of silica and alumina, and also of carbonate of magnesia. It is more correctly a dolomite, resembling in that respect the rock at Red Wing and at Winona, though not having the bright, cheerful

color of the stone at those quarries. It is subcrystalline, rough to the touch, hard, but splitting to thin lenticular chips under the weather. It is of a blue color within, but on exposed surfaces becomes a dirty buff. The grain is close, except for the cavities resulting from absorbed fossils. The fragments into which the stone weathers out are brittle and somewhat sonorous under the hammer. The older portion of the State university contains a large amount of this stone, and its superior durability can there be seen. This part of the Trenton limestone is about 8 or 9 feet thick, and is separated from the blue-stone usually wrought by a thickness of 5 or 6 feet of worthless shaly rock, which builders sometimes smuggle into a wall.

Still higher in the geological scale are limestones that appear in the southern counties, known as Upper Trenton and Galena. The banks of the streams that pass into Root river in the western part of Fillmore county and in southwestern Olmsted exhibit many large exposures of the Upper Trenton, and there are many quarries in it, but they are mainly for quicklime. They might be utilized for building stone, since the rock is heavy, firm, free from shale and sand, and easily accessible. The Galena beds are extensively wrought at Mantorville and at Spring Valley, and somewhat at other points in Fillmore and Olmsted counties, and in northwestern Goodhue county. The color of this rock is buff, sometimes dark buff, although on deep quarrying the heart of the beds shows that its normal color, like most other limestones, is blue. Its composition, like that of the rock at Red Wing and at Winona, is dolomitic, comprising a large percentage of carbonate of magnesia, but it is without the quartz that is found in the limestones along the Mississippi, and is on that account less hard to quarry and cut, as well as less durable. Its texture is open, even porous, with minute cavities, and sometimes with larger openings, due to the absorption of fossils. In this latter case it presents a rough and forbidding aspect. This, however, is not common, the sedimentation having been generally so undisturbed by chemical or mechanical agencies that the layers are yet well preserved. The grain is crystalline and somewhat granular. Minute crystals of brown spar often line the cavities. It sometimes also embraces iron pyrites, which, weathering out, stains the face of the rock with iron rust. The granular texture seen in some parts of this formation, which is a character seen in most magnesian limestones, has sometimes made it pass for a sandstone. As a material for building it is a little surprising that this formation has not been more employed. It occurs in fine exposures in the southeastern part of Goodhue county, abundantly in Dodge county, as well as in Olmsted and Fillmore, along the streams, and can be extensively wrought. It furnishes a building material not only suitable for all ordinary uses in foundations and abutments for bridges, but one that cuts easily to a regular and smooth surface. Its bedding is sometimes heavy, reaching 2 or 3 feet in thickness, and the stone is strong enough to endure both pressure and long weathering. It is of a light and lively color, and in that respect has the advantage of darker-colored stone.

The Galena limestone is quarried at Mantorville for general building purposes and to some extent for monument bases. The principal markets are Rochester, Mantorville, and Spring Valley. The following are some of the buildings in the construction of which the stone has been used: Wright's hotel, two school-houses, the court-house, and Ginsburg's brewery, in Mantorville. Blocks 22 by 25 by 2½ feet may be quarried. The stone is evenly and horizontally bedded in courses varying from 6 inches to 3 feet in thickness; joints are irregular, crossing each other at varying angles. The various quarries here are near each other and furnish the same kind of rock. Mantorville is one of the old and important quarry towns in the state, but of late years, owing to poor wheat crops, there has been but little demand, and the quarries have been comparatively unproductive. The material is a siliceous dolomite containing iron in the form of sesquioxide.

The limestone of Hudson River age is quarried at Clinton Falls, Steele county, near Owatonna, for walls and buildings, but more especially for foundations at Owatonna and in the surrounding country. It is a siliceous dolomite containing protoxide of iron; in color it is a drab; its texture is sometimes slightly vesicular, but usually fine and compact; shows signs of irregular stratification, and is evenly and horizontally bedded in layers from 2 to 6 inches thick. Blocks 4 by 4 feet by 4 inches are the largest that can be quarried, on account of the frequent joints.

The Devonian limestones are of two very different sorts. One kind is found in Fillmore county, southwest of Spring Valley, and particularly along the tributaries of the Upper Iowa river. This stone in all respects except its more even and close texture, being without the porous features, is like the Galena limestone at Mantorville. Its color is the same, but its even and non-vesicular texture is enough to distinguish it from the Galena. The bedding is also less thick, being, when in exposure, usually less than 8 inches, though when quarried it is also in heavy beds. It is a yellowish, magnesian limestone, sometimes with a finely arenaceous composition, and is suitable for most purposes in common masonry. It is tolerably free from calcite lumps, but has some chert nodules. It is, however, generally useful for a cut stone in its outcrops in Fillmore county. It has been but little opened in Minnesota, principally because the region in which it occurs has not yet developed so as to create a demand for first-class stone for building. In Michigan and Ohio this formation supplies some of the most valuable limestone for building. The other sort of Devonian limestone overlies the last, and is much finer grained. It is light-colored, or sometimes nearly white, hard, and fine. It is uniform in grain and texture, and not in the least porous. Some parts of it would make a beautiful white, or nearly white, marble, if it were deeply quarried. In ordinary working it breaks with a conchoidal surface, but by some care a uniform cutting can be made in any direction. Some of the beds of this rock are about 10 inches or a foot thick, but they are more frequently about 4 or 6

inches, and can then be got out in slabs of considerable size. It is a fortunate circumstance that sometimes layers of clay are interposed between the beds, which facilitates their being obtained in sizable blocks. The most favorable point for quarrying this stone is at Le Roy, in the southeastern part of Mower county.

Limestone suitable for all purposes of building is found well exposed for quarrying along Deer creek, at Frankford, in Mower county. The age of this rock is not fully established, but is supposed to be of the Upper Silurian age. This stone is suitable for heavy masonry, being often 3 feet thick or more. The stone has about the same color as that at Le Roy, but is somewhat darker. Its texture is vesicular, with abundant calcite and some chert, and it is apparently a magnesian limestone.

SLATE.

At Thompson, where the Saint Paul and Duluth railroad crosses the Saint Louis river, the Huronian slates have been opened for the production of roofing slate, and with very good success. This enterprise is not now carried on, but there is no known reason why it should not be revived and made profitable. The slate is black, hard, and compact, fine and uniform, contains no spots developing crystals, pebbles, or other defects, and is apparently of the best quality. Considerable quantities which were taken out over ten years ago have been exposed on the ground to the weather at that place, and show no effect from such severe tests. The amount of the supply here is exhaustless, but of course some care must be exercised in selecting the beds for quarrying. Slates of different grades of hardness can be obtained, which will supply material not only for roofing, but for writing slates, tables, mantels, and all other uses to which such slate has been applied. The locality is perfectly accessible from the south by the Saint Paul and Duluth railroad, and from the west by the Northern Pacific railroad.

A good quarry in this slate was opened at Knife Falls, Carlton county, by the Saint Paul and Duluth Railroad Company, in 1880. The quarry is at a point 5 miles north of the Northern Pacific junction, near the northern boundary-line of Carlton county. Considerable stone was taken out, but none has been shipped or dressed in the condition of roofing slate. All that has been quarried was designed for flags, and the pieces are from a quarter of an inch upward in thickness and generally contain about 6 square feet, though some are larger. They are dark blue or nearly black, smooth and uniform, and well adapted for flagging, flooring, or marbleizing. The form of the natural slabs, as determined by transverse joints, is subrhomboidal and rectangular. No prices or markets were established before the whole enterprise, which must have involved an expense of $15,000 or $20,000, was abandoned by the railroad company, which abandonment is said to have been brought about in pursuance of the policy of the company to relinquish all extraneous enterprises and conduct only railroading. This termination of such a movement has had a bad effect on the reputation of the slate. Slates were quarried in 1870 on this formation at another point about 3 miles distant, and the weather has not yet injuriously affected it where used as roofing. This attempt was also very expensive to the owners, and, when the financial stringency came on, it was also abandoned. This formation appears very abundant in Minnesota farther north and east, especially about Vermillion lake, where the slates are less brittle and of a light green color.

PAVING STONE.

For pavement in ordinary roads or in the streets of cities a variety of material has been used, but in general the harder and tougher kinds of rock are the best. Sandstone is altogether too soft, unless it has been hardened into a quartzite by some method of metamorphism. Such changed sandstone is the quartzite at New Ulm and southwestward to Rock county, and also the quartzite or cemented sand-rock of the Cretaceous below New Ulm, in which the cement, being principally silica, has compacted the entire mass so as to form one very tough substance. This latter, however, is probably not obtainable in very large quantities, and its cemented condition is variable and perhaps not extensive. Still, whatever there might prove to be would, especially in connection with the Potsdam quartzites of New Ulm and of Rock and Pipe Stone counties, furnish a supply ample for that part of the state and for a large export to adjoining parts of Iowa and Dakota. The limestones of the Lower Magnesian, viz, those at Winona, Red Wing, Mankato, Kasota, and Shakopee, are better for paving material than other limestones that contain less silica, being firmer and harder and less soluble by water. Of good road material Minnesota has a superabundance. The granites, greenstones, traps, and quartzites form the most conspicuous feature in the geology of the northern and eastern portions of the state. The so-called trap-rock at Taylor's Falls is the most accessible of the firmer kinds of stone, excepting the pebbles and bowlders found in the drift scattered nearly all over the state. The granite at Saint Cloud and Sauk Rapids is also accessible, and is nearly as durable. The gneisses of the Minnesota valley are very suitable for the same use, and the rocks of the north shore, being very largely tough dolerites, are superior for this purpose. Some of the best exposures are at Duluth of stone known as "Duluth granite". These dolerites of the north shore are wrought into rounded forms on the beach by the action of the waves, and sometimes these rounded stones alone constitute the beach. They have been carried by ship-loads from Minnesota to Chicago and other cities for use in paving streets. They are found in considerable numbers in grading the streets of Minneapolis and Saint Paul, associated with similar forms of other hard rock, and are thrown with the dump and buried again. A little thoughtfulness would save thousands of dollars to each city.

FLAGGING.

So far as known, the state is not abundantly supplied with stone that is naturally and easily separable into sheets for flagging. Yet it is to be borne in mind that there has not yet been created a large demand for flag stones, and that perhaps when the demand arises some of the quarries now in operation, or others, will be found to possess a good supply of flag-stones. Some of the beds most likely to furnish such stone of a durable character are the lighter colored, or at least the thinner bedded, portions of the red quartzite at New Ulm, or at some other points southwest of there. In the exposure of this quartzite at Redstone, near New Ulm, some of the lower layers are argillaceous and thin, and can be got in large slabs, which, with proper handling, could be broken to shape and size for flagging; but in general such beds are covered by a large thickness of firm, heavy layers of quartzite.

The Cretaceous beds at Fritz's quarry, a few miles below New Ulm, and at other places near, also will furnish a pretty good flagging, which it would be much easier to obtain than the stone at Redstone, the beds being separated by other layers of incoherent sand-rock. There are places in the Minnesota valley, above New Ulm, where the quarries would also furnish a good flagging stone, but of course, while more enduring in use, this stone would be more difficult to quarry. Of the limestones, or siliceous limestones, the beds of the Saint Lawrence or Shakopee formations are most promising. The former is in outcrop, as already stated, all along the Mississippi river from Winona to Hastings, and thence up the Saint Croix valley to and beyond Stillwater, and the latter is characteristically exposed at Shakopee, Ottawa, Kasota, and Mankato. Some of the thinner beds furnish a very superior stone for flagging, which is now somewhat used for that purpose. At the present time it is generally broken up for lime-burning or is sold as inferior building stone. The exposures of the Saint Lawrence formation at Hebron and other places in Nicollet county, and at Saint Lawrence, nearly opposite Jordan, in the Minnesota valley, are also very favorably situated for obtaining flagging; at Saint Lawrence particularly the beds are of about the right thickness. Some firm slabs of flag-stone are obtained at Kasota.

In the northern part of the state nothing is known that will answer for flagging, unless it be certain layers in the red sand-rock at Fond du Lac, or the argillite at Thompson. The former can be easily tested and readily obtained, but it would be rather soft for such use. It can be got in large slabs, but it would be refractory to work into shape and slippery in use, though very firm and durable when once laid.

IOWA.

By W. J. McGee.

The principal sources of knowledge of Iowa geology are the three reports of Owen, (*a*) Hall, (*b*) and White. (*c*) Unfortunately, the official surveys on which those reports were based were not carried to such detail as to afford more than a general outline of the geological phenomena of the state, and accordingly the published information on the subject is much less full and accurate than could be desired. Moreover, since the last of these surveys was brought to a close, additional natural exposures of strata have been discovered, the number of artificial exposures has been tripled, and, in consequence, beds probably distinct from those officially recognized have been brought to light, and material defects in the official maps have been detected.

In the dozen years that have elapsed since the publication of White's report many data have been collected by different observers. These are in part scattered through various publications, but are yet mainly unpublished. Among the latter are the observations I have made during the past four years, extending over the Cambrian, Silurian, and Devonian systems, which observations, though made in a desultory and unsystematic manner, and imperfectly connected, have been drawn upon almost exclusively in the preparation of the following descriptions, so far as the above-named systems are concerned. The descriptions of the newer systems are based mainly on the works of Hall and of White, especially of the latter, though in nearly every stage the observations of these gentlemen have been supplemented by my own. Since, however, careful and systematic geological work is yet required in every portion of the state, it is manifest that no high degree of accuracy can be claimed. Particularly reliable or particularly unreliable representations will be specifically indicated in the following pages. A few modifications in the classification of the rocks have been introduced for reasons mentioned in the detailed descriptions of stages. Synonymy, etc., may be learned from White's report, already cited.

a Report of a Geological Survey of Wisconsin, Iowa, and Minnesota . . . Made under instructions from the United States Treasury Department. Published by authority of Congress. Philadelphia, 1852.

b Report on the Geological Survey of the State of Iowa. . . Published by authority of the legislature of Iowa. 1858.

c Report on the Geological Survey of the State of Iowa to the Thirteenth General Assembly. Des Moines, 1870.

GENERAL GEOLOGICAL SECTION OF IOWA.

Group. (*Era.*)	System. (*Period.*)	Series. (*Epoch.*)	Stage. (*Age.*)	*Thickness.*
				Feet.
Psychozoic	Quaternary	Glacial	Drift	200
Mesozoic	Cretaceous	Lower Cretaceous	Inoceramus	50
			Woodbury	150
			Nishnabotna	100
			Fort Dodge	35
Paleozoic	Carboniferous	Coal Measures	Upper Coal	325
			Middle Coal	150
			Lower Coal	200
		Sub-Carboniferous	Saint Louis	80
			Keokuk	90
			Burlington	125
			Kinderhook	200
	Devonian	Hamilton	Hamilton	250
	Upper Silurian	Niagara	Niagara	50 to 350
	Lower Silurian	Trenton	Maquoketa	20 to 125
			Galena	20 to 250
			Trenton	75 to 200
		Canadian	Saint Peter	80
			Lower Magnesian	350
			Potsdam	300
	Cambrian	Primordial	Sioux	100

QUATERNARY PERIOD.

Drift.—Under this general term are included the several beds of aqueo-chemical, vegetal, glacial, lacustral, and alluvial origin, which represent no fewer than eight distinct deposits, and which cover the sedimentary strata over more than 99 per cent. of the state. While the thickness of the drift is variable, it is generally sufficient to preclude the economical extraction of the underlying rock for industrial purposes, and at the same time to embarrass geological investigation, except in the deeper valleys of erosion; and over fully one-third of the state its depth and continuity are such as entirely to conceal the older strata.

Over much of the northern half of the state erratic bowlders of granite, syenite, and other crystalline rocks abound in the drift, and are more or less extensively employed for building and ornamental purposes. They are found in greatest abundance and perfection and of largest size in Butler, Bremer, Black Hawk, and Buchanan counties, where, as in all the northern third of the state, they either lie upon the surface or are but partially buried. Farther southward they diminish in size, become wholly buried, and finally diminish in number. The large bowlders have been most largely worked in Buchanan county, chiefly at and near Independence; but they are pretty largely employed for heavy foundations, bases, monuments, etc., at Osage, Mason City, Charles City, Waverly, Marshall, Eldora, and elsewhere. Smaller bowlders are also used for foundations, etc., either in their natural form or simply broken into irregular fragments (by blasting or by plugs and feathers), or, more rarely, dressed, in nearly every county in the northern part of the state, where they serve as a substitute for the inaccessible bedded rocks; but the demand is so variable and the supply so limited that the industry is neither important nor permanent.

CRETACEOUS PERIOD.

Inoceramus.—This newest stage of the sedimentary strata of Iowa consists of three conformable chalky beds, of which only the uppermost is sufficiently indurated to form a weak and friable limestone. It is not known except in the bluffs of the Sioux river in Plymouth and Woodbury counties, and it is practically worthless for purposes of construction, though the upper division is sometimes employed for cheap foundations, etc., in the vicinity of Sioux City.

Woodbury.—The materials forming this stage are either sandstones, generally shaly and impure, or argillaceous, arenaceous, calcareous, or (rarely) bituminous shales. It is exposed along the Missouri and Sioux rivers in Woodbury county. At and in the vicinity of Sioux City the purer sandstone layers are quarried to the value of perhaps $1,000 or $2,000 per year, the product being used for common rubble, riprap, macadam, paving and curb stones, etc. The material is tolerably suitable for such purposes if care is exercised to exclude the obscurely-shaly, or otherwise defective portions. There is so much waste as to enhance its cost, but it can nevertheless be furnished at a less price than stone transported thither from better quarries.

NISHNABOTNA STAGE.—The Nishnabotna stage is mainly a coarse-grained, friable sandstone, generally quite ferruginous, sometimes gravelly and passing into pudding-stone, and rarely clayey. When cemented it is usually by iron, and it hence assumes the reddish brown color of the hydrated sesquioxide. It is frequently obliquely stratified, and is generally massive or with very irregular and obscure bedding and jointage planes. It is exposed along the Nishnabotna river in Cass county, in Guthrie county, and in a few other localities; the only important quarry being at Lewis. A few smaller quarries are operated near Lewis, and others are said to be worked in southeastern Guthrie county.

FORT DODGE.—The stage to which it seems appropriate that this name should be applied is a deposit of nearly pure light gray, regularly-bedded gypsum, resting unconformably upon Saint Louis and Lower Coal strata, and unconformably overlain by drift, supposed to extend over an area of about 25 square miles in the vicinity of Fort Dodge. The bedding is horizontal, and it is generally distantly and vertically jointed. It is also finely laminated horizontally in alternate white and gray lines, the latter containing all the slight impurity with which it is charged. It is quite soft when first quarried, but hardens considerably on exposure. Some years ago it was quite extensively used as a building material, but it has now fallen into disrepute. Among the structures built from it are an arched culvert over Two Mile creek, on the Illinois Central railway, and the depot building on the same railway at Fort Dodge, both of which were erected from 15 to 20 years ago. Four years ago the culvert was seen to be in good condition, and during the past season but little sign of dissolution could be detected in the depot building. Foundations built at about the same time are, however, reported to have given way. It is now almost exclusively employed in the manufacture of plaster of paris.

I have made but few and casual observations in connection with the Cretaceous rocks of the state, and hence their description is mainly taken directly from White's report. It is probable that much of the northwestern third of the state is underlain by Cretaceous strata; but the depth of the drift is so great as to prevent the actual determination of the geographical extent of the system. The classification adopted is that of White, except as regards the gypsum deposit, which is provisionally given a specific stratigraphical designation and included within the Cretaceous system. As shown by White, the deposit is apparently a precipitate of sedimentary character (*Geology of Iowa*, 1870, II, p. 300), and it hence must have been laid down in a basin isolated from the sea and subjected to gradual evaporation: and since the Cretaceous seas extended farther northeast than those of any other age between sub-Carboniferous and Quaternary times, it is regarded as most probable that this little inland basin was filled by sea-water during that period, and desiccated during the elevation that closed that period in Iowa.

The limited information as to the employment of the Woodbury sandstone for building purposes was mainly derived from incidental observations made some years ago; but from reports of a resident during the past season it appears that the material is used to about the same extent as at that time.

CARBONIFEROUS PERIOD.

UPPER COAL.—The materials forming this stage of the general Iowa section are, as far as known, pure, magnesian, argillaceous, arenaceous, and earthy limestones, generally intercalated with shaly bands and partings, together with shales, clays, sandstones, and a thin coal seam. The pure and magnesian limestones are regularly, smoothly, and approximately horizontally bedded, and generally distantly jointed by the "clay seams" of the quarrymen; though the ledges, especially in the pure limestones, are independently cut up into angular blocks of various sizes by irregularly-ramifying vertical "dry seams", which often simulate fresh fractures. The area occupied by this stage is very considerable, though most of it is so deeply covered with drift that the rocks are accessible only along waterways.

In addition to the quarries specifically reported on there are small quarries supplying local demands for common rubble (used chiefly for cheap foundations, etc.) at Glenwood, Malvern, Red Oak, Macedonia, Corning, Bedford, Clarinda, Numa, and Winterset, in southeastern Cass county, in southern Decatur county, and elsewhere, which collectively produce building material to the amount of many thousands of dollars annually; indeed the demand for building stone for all except the more costly structures in the southwestern part of the state is chiefly met by the product of such local quarries. They are, however, so irregularly worked as to render it quite impossible to collect reliable statistics of their operation and product. All of these quarries are in limestone, the sandstones being worthless for building purposes so far as known.

The dolomite, which occurs only at Winterset, and in a few ledges at Earlham, is light buff or grayish-buff, finely saccharoidal, homogeneous, tough, quite free from grit, and seldom penetrated by dry seams. It well resists exposure and the action of frost, and is in all respects an excellent stone. The pure limestone is whitish or light gray, sometimes with a bluish tinge, finely subcrystalline, the fracture being generally conchoidal. It usually occurs in only a few ledges at any point, intercalated with impure limestone, but is not confined to any part of the area of the Upper Coal rocks. It is somewhat injured by dry seams, and does not perfectly resist the action of frost. The impure or argillaceous portions are light buff, yellowish, bluish, and sometimes blue-black, especially when freshly quarried; is approximately homogeneous, fine, compact, and brittle, and much cut up by dry seams. This stone is soon destroyed by frost, especially when kept moist, as at the ground level in foundations. Both the pure and argillaceous phases are remarkably uniform in lithological character over the whole area of the stage.

MIDDLE COAL.—This division of the Coal Measure series consists of shales, clays, sandstones, and limestones, with half a dozen thin coal seams, the limestones and sandstones occurring in thin, discontinuous beds. Its strata occupy a variable, tortuous belt, bounding the area of the newer stage, but not yet satisfactorily separable, geographically, from the Lower Coal stage. St. John mentions (*Geology of Iowa*, 1870, I, p. 284) that the limestones of this stage are quarried in the western part of Dallas county, and that the sandy ledges afford a fair freestone near Adel and south of Indianola; but it appears, from inquiries made, without visiting these localities, that neither here nor elsewhere are these rocks systematically quarried to any considerable extent.

LOWER COAL.—The lowest member of the coal-bearing rocks in Iowa is mainly composed of shales, clays, and friable sandstones, with occasional thin layers of impure limestone and a number of valuable beds of coal, the whole occupying a very considerable but extremely irregular area. Over this area (which was largely determined by Hall and White) the strata are tolerably uniform in character and approximately horizontal, though sandstones predominate toward its eastern and northern margin, and in the isolated outliers, and the beds are apparently disturbed by a number of gentle parallel undulations which coincide in direction with the principal waterways. In some cases certainly, and apparently in nearly all, the lines of erosion follow the anticlinals. Moreover, its attenuated margin is deeply lobed by the erosion of the tributaries of these streams and by all minor waterways which originate within its area. Accordingly it is quite possible that the terminal portions of many of the eastwardly-extending lobes are nearly insulated; while conversely, the Story county, Pella, and other sub-Carboniferous exposures may be completely surrounded by coal-bearing strata. The rock occurs in the southeastern part of Jones county, near Oxford, but its extent is not known. A brown sandstone also occurs in the eastern part of Delaware county, 5 miles south of Dyersville, and a ferruginous conglomerate is found in small quantities in the northeastern part of Howard county; but these exposures equally resemble the Nishnabotna sandstone, and may possibly not belong to either the Cretaceous or the Carboniferous systems.

The limestones of the stage are, so far as known, worthless for building purposes; but the sandstones, which are usually coarse, more or less ferruginous, heavily bedded or massive, rather distantly jointed, and often obliquely laminated, are quarried in many localities, chiefly near the margin of the area occupied by the stage, or in its isolated outliers. At Red Rock (9 miles north of Knoxville) it yields an excellent freestone of brick-red color, which attracted much attention a few years ago, but which is now mostly abandoned in consequence of the opening of quarries in superior limestone and sandstone strata of the Saint Louis stage in the vicinity. A less valuable freestone is reported to be quarried in a small way near Ripley, and in Boone county, 10 miles west of Sheldahl. At Steamboat Rock (4 miles north of Eldora), Eldora, near Marshall, at Kellogg, and south of Sigourney, a coarse, brown, friable, ferruginous sandstone, sometimes conglomeratic, which supplies local demands for common masonry, is quarried in a primitive manner whenever the material is called for; the aggregate annual product (excluding Eldora) is, on an average, about 80,000 cubic feet, worth about $2,500, but the output appears to have been less than usual for the past year or two.

The sandstones of the outliers are, as a rule, superior to those of the Lower Coal area proper. At the Dutch colonies, in Iowa county (East Amana, Amana, Middle Amana, Höhe Amana, West Amana, and Homestead), lying from 5 to 10 miles east of Marengo, it is finer and firmer than in the localities previously mentioned, and generally obliquely laminated. It is employed in the construction of the principal buildings, including mills and factories, in the several towns. The laborers of the colonies work the quarries whenever building material is required, or they are not otherwise engaged, moving about 75,000 to 125,000 cubic feet of rubble per year; but since this labor has no financial equivalent, and the product is common property, the value of the material is indeterminate. In the outliers of Muscatine and Scott counties the rock is still more extensively utilized as a building material. In the western part of this area it is lithologically similar to that found at Amana, or somewhat coarser and more friable, as in the Hare and Starke quarries; but eastward it is finer and less ferruginous, as in a quarry near Buffalo and the Goetsch quarry, in Davenport, where it is fine, uniform, clean, imperfectly cemented, and light buff or white in color. In the last-named quarry it reposes unconformably upon Devonian limestone, both being quarried, but neither extensively.

SAINT LOUIS.—This stage is made up of three distinct divisions. The uppermost of these consists mainly of pure limestone, sometimes brecciated or concretionary, sometimes regularly bedded, compact, finely subcrystalline, homogeneous and brittle, with a conchoidal fracture, and is overlain by a bed of clay, the whole being some 40 feet in thickness. The middle member is a sandstone or freestone, usually regularly bedded, distantly jointed, firm, homogenous, and hard; its thickness never exceeding 20 feet, so far as known. The lowest bed is an equally homogeneous, compact, regularly-bedded, distantly-jointed dolomite of unusual strength, fineness, and toughness. The area over which the strata of this age form the floor of the drift is not known with sufficient accuracy to permit of separating this from the older stages of the sub-Carboniferous series; but its outcrops are known in Lee, Des Moines, Henry, Washington, Van Buren, Jefferson, Keokuk, Wapello, Mahaska, Marion, Story, Hamilton, and Webster counties; its identity in the second as well as in the last three of these counties being stated on White's authority.

The uppermost division is the least valuable as a building material, though it is largely quarried for that purpose at Franklin, Mount Pleasant, Ottumwa, Chillicothe, Givin, Sigourney, Ames, Fort Dodge, Webster City,

and elsewhere. In all of these localities it forms a fair, sometimes excellent, building stone. It has also been quarried for use in lithography, chiefly near Farmington, where the rock is similar, lithologically, to that found at Franklin. It is no longer used for this purpose, since it has been found to contain too many dry seams, often cemented by crystalline carbonate of lime. Its ordinary color is light buff, light gray, or nearly white, sometimes with a bluish tinge; and its normal texture, where of value as a building material, is fine, homogeneous, brittle, and sometimes very hard, as at Ottumwa. This phase resembles the pure limestone of the Upper Coal stage. It is, however, impure in its northwesterly extension. At Ames and at Webster City it is generally buff or yellowish in color, somewhat earthy or argillaceous, and quite similar to the impure portions of the Upper Coal limestone; while at Fort Dodge it is almost silty in part, dark blue or black when freshly quarried, though weathering to gray, and very erratic and refractory under the hammer when first extracted. It need hardly be said that the stone from these quarries does not well resist the action of frost. Little is known of the Webster City quarry further than that it supplies local demands for cheaper masonry, and that it is not largely operated. The city is in part supplied with better stone from the Farley quarries.

The middle division is largely quarried at Keokuk, Fairfield, Mount Pleasant, and Dudley. At Fairfield it is composed of siliceous sand in a calcareous matrix, and is irregularly bedded and closely jointed, rendering it difficult to find blocks of large dimensions; but it is so hard, and resists disintegration so perfectly, that a door-sill in constant use for twenty years exhibits scarcely perceptible wear. Ten miles northeast of Fairfield a small quarry, used locally, is said to yield much larger blocks of similar quality. Near Oskaloosa the rock is reported to be much the same as at Fairfield. It is here used for millstones with partial success. At Keokuk and at Mount Pleasant, but especially at Dudley, the ledges are smooth, uniform, distantly jointed, and free from dry seams, permitting the extraction of blocks 10 by 20 feet, or larger, though it is here less hard and indestructible than at Fairfield. The rock is generally gray or bluish-gray in color.

The lowest and magnesian member is extracted at Keokuk, Mount Pleasant, Chequest creek (5 miles southwest of Kilbourne), Brighton, Washington, Givin, Ottumwa, Dudley, Tracy, Pella, Durham, and Knoxville. At Washington, Brighton, and Knoxville it sometimes exhibits a stylolitic structure, and is in addition rather irregularly stratified and closely jointed. At Durham, Pella, Tracy, Dudley, Givin, Chequest, and Mount Pleasant, however, it is regularly and rather heavily bedded, quite homogeneous, and distantly jointed. Its color varies from bluish-gray at Washington and Knoxville to bluish-buff at Chequest, yellowish-buff at Pella and Tracy, light buff at Givin and Durham, and whitish at Mount Pleasant; and in texture it is finely saccharoidal or compact, homogeneous, and tough, resembling in some cases the Upper Coal dolomite. At Chequest it is susceptible of a fair polish, and is widely known as "Chequest marble", and at Tracy, Pella, and elsewhere it may be carved with great facility. The bluish tinge is remarkably permanent, as at Washington, where fractures exposed for a number of years exhibited no perceptible alteration in color, and appeared almost as fresh as if just taken from the quarry.

KEOKUK.—This stage comprises two members, the upper being an irregular mass of shaly or calcareo-siliceous strata, abounding in geodes, while the lower consists of compact grayish or bluish limestone, generally regularly bedded, with shaly partings. The area covered by the rocks of this age is known to be limited, though it cannot yet be delineated cartographically. The only localities where these rocks are known to occur are portions of Lee and Des Moines counties, and a narrow belt along the Des Moines river, in Van Buren county, where they have been brought to the surface by one of the gentle anticlinals already referred to, coupled with the erosion of the valley. The stage appears, from White's observations, to attenuate and perhaps disappear toward the interior of the state.

The pure limestones of Keokuk age, like those of the Saint Louis and Upper Coal stages, are finely subcrystalline, compact, brittle, homogeneous, and hard; light gray, whitish, and slightly bluish in color; but the larger portion is earthy or argillaceous, as is much of that of the Upper Coal. These impure limestones are buff, yellowish, or bluish, uniformly bedded, separated by shaly partings, which sometimes graduate into the ledges and again develop into considerable layers of clay; they are distantly jointed, but much cut up by independent systems of dry seams ramifying through each ledge, and liable to suffer disruption and disintegration when exposed to the atmosphere and frost. The Keokuk strata are not extensively quarried, the important quarries being confined to Keokuk and Bentonsport.

The smaller quarries in the vicinity of Keokuk and near Bonaparte, 5 miles southeast of Bentonsport, are also in this stage. The material is employed to some extent for dressed caps, sills, etc., as well as for rubble, macadam, and other common grades of building stone.

BURLINGTON.—This stage, like the Saint Louis, is made up of three well-marked beds. The uppermost division consists mainly of light gray, whitish, or buff, regularly bedded, compact, subcrystalline limestone of approximate purity, with occasional clayey or shaly partings, becoming siliceous, cherty, and irregular toward the top. The middle member is predominately siliceous, but it is generally shaly, seldom sandy, and without compact and regular strata. The lowest division is a yellowish or grayish, compact, pure limestone, regularly and rather heavily bedded centrally, but cherty both above and below. The highest member constitutes about one-half and each of the two lower divisions about one-fourth of the total thickness of the stage. Its geographical extent is probably still less than that of the Keokuk division of the sub-Carboniferous rocks, since it is known only at its typical locality, Burlington, along lines of erosion in Des Moines and Louisa counties, and in the northern part of Washington

The Burlington rocks are practically identical with those of Keokuk, and are similarly used for common masonry and occasionally for dressed work. They are, however, extensively quarried only at Burlington. Portions of the uppermost division are nearly white in color, fine, compact, homogeneous, and hard, with a conchoidal or splintery fracture, like the so-called lithographic limestone of the Saint Louis stage. This phase has been used to some extent for ornamental purposes, but it contains too many incipient fractures and is too liable to unexpected disruption to be of special value.

KINDERHOOK.—The rocks of this age, which occupy a singularly long and narrow belt, are of rather variable character. At Burlington nearly the whole thickness of the stage is made up of shales and clays, with a few unimportant beds of limestone at the top, which include oolitic and magnesian layers. This phase is tolerably constant throughout Des Moines county, the dolomite forming the upper, the oolite the middle, and the shale the basal and principal portion. Along English river in Washington county the dolomite is considerably thicker (the oolite remaining inconspicuous), and, though rather earthy and irregularly bedded, is quarried in a small way near Riverside and Kalona, yielding common and heavy rubble, locally used for foundations, well-rock, bridge-piers, etc.; the average annual product of the several quarries probably falling below $1,500 in the aggregate. The stage is next known in Tama and Marshall counties, on both sides of the Iowa river. Here the basal shaly division is mainly absent or concealed beneath the river level, not to appear again in Iowa, and the two calcareous divisions are of predominant importance. At Montour the oolite is heavily bedded or massive, regularly and tolerably distantly jointed, and gray or bluish-gray, weathering to buff or yellowish. On the opposite side of the river the same oolite is less heavily and more regularly bedded, and is quarried by a number of individuals for lime and common rubble, the rubble supplying the vicinity and the towns of Toledo and Tama. These quarries are generally operated by farmers during leisure time, and yield collectively perhaps 75,000 cubic feet per year, worth about $750 at the quarries, or $3,000 delivered. A similar phase is presented at Conrad, Grundy county, where the material is more extensively utilized. Near Le Grand the uppermost or magnesian bed shows a thickness of over 40 feet, while the oolite is mainly beneath the river. Here the dolomite is regularly and rather heavily bedded, distantly jointed, compact, fine, and homogeneous, and generally buff, whitish, or yellowish in color. The coarser ledges are here so extensively used for rubble, bridge work, dimension stone, and other purposes as to require a railway station for the sole use of the quarry; while the finer ledges, which are often beautifully veined by iron peroxide, are sawed into slabs and shipped to distant markets for ornamental purposes, under the name of "Iowa marble". Near Dillon the same dolomite is unusually hard and firm, and is the sole member exposed. At and near Iowa Falls the two uppermost divisions of the same stage (as identified by White) again appear; but here the limestone is pure, finely subcrystalline, compact, hard, and without a trace of oolitic structure, and the dolomite is remarkably magnesian, generally heavily but regularly bedded, though in part massive and tolerably distantly jointed. Both members are quarried quite largely. The purely calcareous bed here resembles lithographically the brittle white limestone of the Burlington, Keokuk, Saint Louis, and Upper Coal stages. Several small quarries have been opened in the Kinderhook strata toward and above Alden, along the Iowa river; but their product is insignificant. At Humboldt and Dakota both the oolitic and subcrystalline phases of the middle bed, as well as the magnesian division, are exposed and largely quarried. Near the headwaters of Lizard creek the purely calcareous division again approaches the surface over a considerable area, and is exposed in a number of localities in both the oolitic and subcrystalline aspects. It is here quarried in a small way by half a dozen individuals in both Humboldt and Pocahontas counties, the total value of the annual product falling short of $1,000. The material here appears to be of unusual strength, hardness, and homogeneity, is regularly bedded and not very closely jointed, and promises to be of great value when the quarries are properly opened and adequate means of transportation provided. In addition to the foregoing there are small quarries near Ackley and Hampton which yield thinly-bedded, "shelly", (*a*) irregular limestones representing this stage, and another of like character is said to exist near Eldora, where a ravine cuts through the Lower Coal sandstone. The product of these quarries is trifling, and the real value of the material is very small since the use of it is almost an injury to the consumer.

DEVONIAN PERIOD.

HAMILTON.—The Devonian rocks of Iowa are extremely variable, both lithographically and paleontologically, but our knowledge concerning them is meager. The predominant lithological phases may be enumerated and described in the order of their excellence:

1. The "Old State House" dolomite.
2. The Mason City dolomite.
3. The Mason City limestone.
4. The La Porte limestone.
5. The Osage dolomite.
6. The Buffalo limestone.

a The convenient term "shelly" (probably a corruption of *shaly*) is frequently applied by quarrymen in this state to rock which separates into irregular plates, generally an inch or less in thickness, and a foot or more in diameter. Such rock may not be shaly, as shown by the comparative purity of the Kinderhook limestone where it exhibits this phase. The phrase "excessively thin-bedded" might be equivalent, if the limited lateral extent of the plates were also borne in mind.

7. The Iowa City limestone.
8. The Waverly limestone.
9. The Independence limestone.
10. The Cedar Rapids limestone.
11. The Fayette breccia.
12. The Rockford shale.
13. The Independence shale.

1. The first of these is a peculiar, heavily-bedded or massive, slightly-magnesian gray limestone of remarkable homogeneity, toughness, and durability, largely made up of comminuted fragments of fossils, chiefly *Atrypa reticularis*. It is found at the North Bend or Old State House quarry, 9 miles northwest of Iowa City, not visibly associated with other strata; and only since the collection of statistics for the Census Office was completed has it been found to pass beneath apparently conformable strata of limestone of the Iowa City phase at Roberts' ferry. It is not known except in the immediate vicinity of the great bend in the Iowa river.

2. The Mason City dolomite is a rather heavily and regularly bedded brown and brownish-buff, distantly jointed, saccharoidal, homogeneous, tough, and compact magnesian limestone, lying conformably beneath pure limestone strata, and only known in the deeply-eroded valleys of Lime and Willow creeks at Mason City.

3. The third phase is a light gray or white, compact, homogeneous and brittle, finely subcrystalline, pure limestone, usually rather heavily bedded and distantly jointed, though considerably cut up by independent systems of fractures in each ledge. It closely resembles the pure limestone of the Upper Coal at Earlham, Stennett, Corning, and other localities; of the upper division of the Saint Louis at Franklin, Farmington, Mount Pleasant, Ottumwa, and elsewhere; of the Keokuk and Burlington at their typical localities; and of the middle division of the Kinderhook at Iowa Falls. Similar rock occurs elsewhere in occasional ledges, as at Garrison, Waterloo, Orchard, Floyd, Marble Rock (where the name of the town was derived from it), Osage, and Mitchell. The phase indeed appears to graduate into that of Iowa City on the one hand and into that of Waverly on the other, though it is approximately uniform throughout at Mason City.

4. The La Porte limestone is rather heavily and regularly bedded, compact, homogeneous, rather finely subcrystalline, but at the same time slightly tough. It is not quite pure, is somewhat unctuous to the touch, resists the action of frost fairly, and resembles the Mason City limestone as regards jointing. It appears to be normally bluish-gray, changing to gray or whitish on oxidation; but, as in the Saint Louis dolomite of Washington and Knoxville, the alteration is accomplished so slowly that partially-oxidized blocks remain distinctly mottled for years. A precisely similar phase has not been detected elsewhere, though certain ledges of the La Porte quarry are essentially identical with certain ledges occurring at both Iowa City and Waverly.

5. The Osage dolomite is a somewhat earthy and slightly magnesian limestone of light buff or yellowish color, and of tolerably fine, homogeneous, and compact texture. It is regularly bedded, sometimes with earthy, shaly, or cherty partings, rather distantly jointed, but sometimes independently seamed. It exhibits in a slight degree the tendency to become separated into angular fragments on exposure to the atmosphere, and especially to frost, which characterizes all of the inferior rocks of this stage. It is of rather variable character, and can only be arbitrarily separated from portions of the Waverly limestone. It occurs associated with limestones of the Mason City and Iowa City phases at Osage, Mitchell, Saint Ansgar, and Orchard; with the Waverly limestone at Waverly and Waterloo; with the Mason City limestone at Marble Rock (where it exhibits but very slight tendency to fracture on exposure), and with the Iowa City, Buffalo, Independence, and Iowa City phases at Davenport.

6. The Buffalo limestone is irregularly bedded, obliquely and rather closely jointed, blue, but weathering to gray within a year or two after quarrying, generally abundantly fossiliferous, and extremely hard, brittle, and refractory. It is quarried at and near Buffalo, where the fossiliferous portions are slightly used for ornamental purposes, chiefly for paper-weights, table-ornaments, and the like, large pieces of uniform character being difficult to procure. It is liable to become fragmentary on exposure. A somewhat similar but less hard and pure fossiliferous limestone is found at Charles City and Nashua, and unfossiliferous rock, resembling that of certain ledges of the Buffalo quarry, occur at Davenport, West Union, and in a few other localities.

7. The phase assumed at Iowa City is that of a non-magnesian but sometimes argillaceous, fine-grained, subcrystalline limestone, blue or even black on fresh exposure, but rapidly weathering to gray, buff, or whitish. It is tolerably regularly bedded, with occasional shaly or clayey partings, generally distantly jointed, but much cut up by independent systems of dry seams and fractures of fresh aspect, and it is quite disposed to become fragmentary on exposure. It occurs at Iowa City, Roberts' ferry, Muscatine, Atalissa, Garrison, La Porte (in the five last-named localities associated with other phases), Solon, Fairfax, Marion, and elsewhere. At Bristow the rock is quite similar, and at Rock Falls and West Union (in part) it partakes somewhat of the character of the Buffalo limestone. At Iowa City and Roberts' ferry it abounds in crystalline masses of the Hamilton corals, *A. cerrularia davidsoni* and Favosites (of two or three species), forming respectively the Bird's-eye and the Fish-egg varieties of the so-called Iowa City marble.

8. The Waverly limestone differs from the last in being more earthy, slightly magnesian, more yellowish in color, and still more disposed to become fragmentary on exposure. It occurs at Waverly, Shell Rock, Waterloo, Independence, Raymond, Vinton, Davenport, and Chatham, generally associated with other phases. Some blocks obtained a number of years ago from the latter locality, however, resemble the La Porte stone.

9. The Independence limestone is hard and brittle, blue, but weathering to gray, irregularly stratified or shelly, and regularly and closely, though often obliquely, jointed. It prevails near the eastern margin of the stage, as near Cresco and Lime Springs, north of Waucoma, at Fayette, Quasqueton, Independence, and in several smaller quarries. It is usually fossiliferous, fragmentary, and somewhat similar to the Buffalo limestone.

10. The Cedar Rapids limestone somewhat resembles that of Iowa City, save that it is without regular jointing or bedding, and is so extremely fragmentary as to be worthless, except for macadam, railway ballasting, etc. It occurs at Cedar Rapids, west of Mount Vernon, at Atalissa, and in part of the Davenport quarries, where it is associated with other phases.

11. At Fayette, Quasqueton, and elsewhere, a bed consisting of angular fragments of compact, brittle limestone, embedded in a matrix of similar material, occurs. It is of no value for purposes of construction.

12 and 13. Neither the Rockford nor the Independence shales yield materials that can be used for building purposes in their natural condition. Both are made up of shales and clays.

It will be observed that a number of the quarries mentioned in the foregoing paragraphs are not represented in the tables. All of these are small, except a few which have been practically abandoned within a few years. More than thirty different openings have been visited during previous years. In the aggregate the average annual product of these small Devonian quarries is about 1,000,000 cubic feet, and the value of this at the quarries is about $22,000; though the value of the stone used for building purposes is considerably less than this. The material has been used mostly for foundations and underpinnings; some for bridge work, flagging, sills, etc., and some for railway ballast and for macadam. Most of it has been used in the vicinities of the quarries; a little has been shipped from Rock Falls and from Nashua.

The Devonian rocks of the state have been casually examined by a number of geologists in different localities, and have been referred to several stages, including the Chemung, Hamilton, Marcellus, Corniferous, and Upper Helderberg; but in view of the meager knowledge of the several beds yet acquired, it has been deemed the least objectionable course to provisionally group all together under the name of the single stage to which they were assigned by White.

UPPER SILURIAN PERIOD.

Niagara.—This sole stage of the Upper Silurian, as found in Iowa, is nearly everywhere a buff, brownish, yellowish, or whitish dolomite; though hard, brittle, and vesicular, non-magnesian masses of gray color, burning into excellent lime, occasionally appear. Considerable portions abound in chert, which usually exists in the form of nodules; but it permeates the material sometimes to such an extent as to form continuous but generally vesicular and irregular ledges, the cavities being filled with dolomite. Other portions are friable, cavernous, vesicular, destitute of homogeneity, shelly, or cut up by dry seams. All such portions, which collectively constitute by far the greater part of the stage visible from the surface, are of course quite worthless for other constructive purposes than road-making. The portions extensively utilized for building material are either regularly and rather heavily bedded and distantly jointed, finely saccharoidal, homogeneous, and tough, and of buff, light buff, or whitish color, as at Farley, Le Claire, Littleport, Volga, Cascade, Clay Mills, Maquoketa (in part), Buena Vista (in part), Princeton, and in most of the smaller quarries of Clayton, Dubuque, Jackson, and Scott counties; finely laminated horizontally, distantly jointed, and without dry seams, finely saccharoidal and tough, and of buff, yellowish, or whitish color, as at Anamosa, Stone City, Mount Vernon, Olin, Hale, Fairview, and Buena Vista (in part); heavily bedded or massive, distantly jointed, saccharoidal, moderately tough and firm, and brown, brownish-buff, or brownish-yellow in color, as at the Williams quarry (between Postville and Clermont), Waucoma, Cresco, Brainard, and Foreston; irregularly bedded and jointed, somewhat friable, finely vesicular, imperfectly homogeneous, and varying from brown to white in color, as at Clinton, Lyons, Comanche, and Sabula (in part); tolerably regularly but variably bedded and distantly jointed, though with occasional dry seams, firm, hard, and somewhat brittle, buff or light buff, with veinings of oxide of manganese, as at Delhi, Monticello, Central City, Maquoketa (in part), Sabula (in part), De Witt, and Tipton; or, finally, tolerably regularly bedded and not distantly jointed, fine, compact, homogeneous, brittle, and blue or light blue in color, as at Manchester, where alone this aspect has been seen. In nearly all of these phases the rock discloses occasional dry seams, which are generally straight, diagonal to the jointing, vertical, and discontinuous, often terminating in both directions in a single block; which seams may be partially or wholly cemented by crystalline calcite or dolomite, generally stained with iron oxide, and never simulate fresh fractures. They are seldom abundant in the larger quarries, but are nearly everywhere a source of some annoyance to the quarrymen, since they are most likely to occur in the larger blocks. The great importance of this stage as a source of building material has already been pointed out.

The number of small quarries not represented in the tables is about 40, the average annual product of which is about 800,000 cubic feet of stone, valued at the quarries at about $18,000. The stone is used almost exclusively for foundations, principally in the vicinity of the quarries.

LOWER SILURIAN PERIOD.

Maquoketa.—The materials forming this stage are mainly shales and clays, with occasional irregular and discontinuous beds of impure limestone; none being of value for building purposes. Its strata only appear in a

narrow belt along the eastern margin of the Niagara stage. The stage becomes so attenuated in thickness in its northwesterly extension as to be quite unimportant both stratigraphically and geographically, though it can be traced to the north line of the state.

GALENA.—The greater part of the Galena stage consists of heavily bedded or massive and rather distantly jointed buff dolomite, of firm and tolerably compact texture, though sometimes vesicular or cavernous; but its upper portion is more argillaceous, regularly bedded, with shaly partings, and with its ledges independently but distantly fissured. The area occupied by the stage is inconsiderable, though, like the Maquoketa, its attenuated northwesterly extension can be traced quite to the state line. The rocks of the Galena stage are extensively quarried only at Dubuque, but they are extracted for local consumption near Elgin, at Elkader, near Massillon (4 miles west of West Union), and in a few other localities; the total product of these small quarries reaching about 50,000 cubic feet, worth not over $1,000. Twice this amount should also be added for the small quarries at Dubuque not specifically reported.

TRENTON.—In its more southerly exposures this stage is mainly composed of compact, hard, and brittle, blue or bluish-gray limestone, frequently rich in fossils, irregularly bedded, often shelly, rather closely jointed, and disposed to disintegrate rapidly. Northwardly it increases greatly in thickness, mainly by the addition of beds of clay and shale. It is occasionally buff or grayish in color in shallow quarries (*i. e.*, those of less depth than that to which oxidation has extended), destitute of fossils, and slightly argillaceous, when it considerably resembles the Iowa City phase of the Hamilton. The hard, brittle, fossiliferous portions, which are not greatly different from the Hamilton limestone as found at Buffalo and Charles City, are also generally slightly argillaceous, the clay appearing in irregular dirty lines or blotches after exposure.

The rocks of the stage are largely quarried at Decorah and Waukon. At Florenceville they are extracted for rubble and dimension stone to the extent of some 30,000 cubic feet, worth about $750 annually, the material supplying local demands, and being moved occasionally to Cresco and neighboring towns. The rock is here fine, compact, and brittle, breaking with a conchoidal fracture, and ringing under the hammer. It is normally blue, but is bluish-gray near the surface. At a depth it is massive, but near the surface it is divided into somewhat irregular ledges by smooth, clean, horizontal fissures. At Bluffton (between Florenceville and Decorah) it is quarried for local use to about as great an extent, though the value of the product is probably below $500. At Elgin, Frankville (6 miles northwest of Postville), Postville, and Clayton there are local quarries whose average product will equal that of Bluffton.

At Bluffton, Frankville, and Clayton the dark blue, fossiliferous phase is represented; but at Elgin and at Postville the rock more resembles that of Florenceville, though containing occasional, and sometimes abundant, trilobites. At Guttenberg both phases are tolerably largely quarried, perhaps half of the buildings in the town being constructed from Trenton limestone extracted in the immediate vicinity. The annual product of the two or three quarries here has been less than usual for a few years, but probably reaches 100,000 cubic feet, worth about $2,000. The stone is used for rubble, dimension work, and road material. A small quarry at Buena Vista (5 miles below the mouth of Turkey river) has yielded material employed in the construction of a large warehouse, and a large amount of railroad ballasting, but the average product is below $500 per year. In addition to these there are many small and unimportant quarries, some of which supply but one or two consumers, scattered over the whole area occupied by the Trenton stage.

SAINT PETER.—This stage is literally a bed of siliceous sand of remarkable purity and uniformity. It is nowhere sufficiently indurated to form a valuable building material in its natural condition.

LOWER MAGNESIAN.—Rocks of this age only appear in and along the valleys of erosion in the northeastern part of the state, where they form the summits of the picturesque bluffs of the Mississippi and the Oneota rivers and their tributaries. The material is essentially a coarse, saccharoidal, vesicular, cavernous, and non-homogeneous light buff dolomite, usually heavily but rather irregularly bedded, and without well-defined jointage planes. It is only rarely that the material is at the same time so firmly indurated, so free from irregular cavities and crystalline nodules, so homogeneous in texture, and so uniformly bedded as to be available as a building stone, and even where these several conditions are as favorable as they are ever found to be, the rock is rather coarse, irregular, and otherwise inferior. Its resistance to atmospheric action is, however, eloquently attested by the mural precipices, castellated battlements, slender pinnacles, and rugged declivities which combine to form the magnificent scenery for which its area is justly famed. It is extensively quarried only at McGregor and Lansing, though, like the Trenton, it abounds in unimportant quarries which sometimes supply but a single consumer.

In Minnesota this stage has been separated into three members (Shakopee, Jordan, and Saint Lawrence) by N. H. Winchell, while in Wisconsin a like number of probably not equivalent divisions ("Main Body", Madison, and Mendota) have been recognized by Irving; but none of these divisions can be either stratigraphically or geographically traced, nor have they indeed been clearly identified in Iowa.

POTSDAM.—This stage is predominantly sandy, and consists mainly of imperfectly-cemented sandstones, with occasionally shaly intercalations which sometimes develop into considerable beds of fossiliferous shale. It is exposed only in the walls of the deep valleys occupied by the Mississippi and Oneota rivers and their principal tributaries. It is not known to be quarried except at Lansing, where it forms an inferior material for common masonry. (The Potsdam of Hull and White is the equivalent of the Saint Croix of N. H. Winchell.)

SIOUX.—As developed in Iowa, the Potsdam sandstone is made up of hard, brittle, homogeneous, and rather fine pink or reddish quartzite, irregularly bedded or massive, and closely jointed, the jointage planes being frequently oblique to the vertical and not rectangular in the horizontal plane. It is found only in the extreme northwest corner of the state, and extends thence into Minnesota, where it is denominated Potsdam by N. H. Winchell.

There is a possibility that quarries of some importance have not been reported from some of the counties in this state. There are 19 counties known to be so deeply drift-covered as to be destitute of exposures of bedded rocks. These are Audubon, Carroll, Clay, Crawford, Decatur, Dickinson, Emmet, Fremont, Greene, Harrison, Lyon, Osceola, Monona, O'Brien, Palo Alto, Sioux, Wayne, Winnebago, and Wright. There are 32 counties in which there may be some small quarries which have not been indicated, though all possible inquiries as to their existence were made in passing through. These are Adair, Appanoose, Boone, Clarke, Dallas, Davis, Des Moines, Guthrie, Hamilton, Henry, Humboldt, Jasper, Jefferson, Keokuk, Lee, Louisa, Lucas, Madison, Mahaska, Marion, Mills, Page, Plymouth, Polk, Ringgold, Shelby, Union, Van Buren, Warren, Washington, Woodbury, and Worth.

The remaining 48 counties were so thoroughly examined that it is quite certain that no important omisssions have been made.

MISSOURI.

By G. C. BROADHEAD.

GENERAL GEOLOGICAL SECTION.

1	Quaternary	Alluvium. Loess. Drift.				
2	Tertiary?					
3	Cretaceous.					
4	Carboniferous	Coal Measures	Upper Coal Measures. Middle Coal Measures. Lower Coal Measures.			
		Sub-Carboniferous.	Chester group. Saint Louis group. Keokuk group. Burlington group.			
			Chouteau group	Chouteau limestone. Vermicular sandstone and shales. Lithographic limestone.		
5	Devonian.					
6	Upper Silurian.					
7	Lower Silurian	Hudson river				60
		Receptaculite, or Galena group				40 to 130
		Trenton				100 to 200
		Black River and Bird's-eye				50
		Calciferous	Magnesian limestone series	First Magnesian limestone		150
				First or saccharoidal sandstone		130
				Second Magnesian limestone		200
		Potsdam		Second sandstone		150
				Third Magnesian limestone		300
				Third sandstone		80
				Fourth Magnesian limestone		300
			Potsdam sandstone			5 to 90
8	Archæan	Porphyry	Huronian.			
		Granite.				

Feet.

ARCHEAN.

This includes the granites and porphyries and their associated and intrusive beds in southeast Missouri. The granites are generally coarse in texture, feldspathic and quartzose, deficient in mica, red in color, or else of various shades of gray, sometimes blending into a reddish gray. They crop out in massive beds in the northern portions of Iron and Madison counties and in the southern part of Saint François county, with isolated exposures in Sainte Genevieve and Crawford counties. They afford our best quality of building stones. In some localities there is evidence of disintegration and decomposition on a grand scale; as, for example, 8 miles west of Fredericktown. At this place a well sunk 75 feet in depth passed entirely through granitic sand. In the western part of Madison county, at Lloyd's, south of Blue mountain, we also find evidence of considerable disintegration. These are probably due to chemical causes.

The phenomenon of rocking-stones is exhibited near the Ozark quarries, 4 miles southwest from Iron Mountain.

In the northern part of Madison county, east of the Saint François river, gray porphyritic granite appears over an undulating district near the Iron Mountain railroad. West of the Saint François river, the red granite rises into mountain peaks.

A syenitic granite forms a "shut-in" (*a*) on Saint François river near the Einstein mine, forming the "rapids" in Saint François river. It is traversed at this place by a dike of black dolerite 44 inches wide bearing S. 60° W. A few miles north of this, also on the river bank, we find it containing numerous specks and scales of micaceous iron and also much pyrites. Half a mile west the granite is traversed by a narrow dike of black dolerite 11 inches wide at the north end and 4 inches at the south end. From the north end it bears S. 32° W. for 30 feet, thence it gradually curves to S. 82° W. a distance of 5 feet. The adjacent granite wall has been slightly darkened and indurated by contact.

At the "Lloyd" place, in Sec. 15, T. 33, R. 5 E., a shaft in decomposed syenite has revealed a vertical dike 18 inches wide bearing northeast and southwest. Two hundred feet northwest another shaft reveals a north and south dike of similar rock 2 feet wide. The dike is of a gray dioritic character. A quarter of a mile east there is a greenstone dike 8 feet wide bearing a little west of north. Washings of sandy débris thrown out show a good deal of deep black magnetic-iron sand. Washings in the roads at several places within a few miles also reveal a good deal of this sand. In the southern part of Saint François county, west of Saint François river, a pit has been sunk on a rich deposit of micaceous iron which, being very soft, was at first supposed to be graphite.

The granite is also sometimes traversed by quartz veins, as in Sec. 2, T. 33, R. 5 E., and Sec. 6, T. 33, R. 6 E.; also on Cedar creek, where very large quartz crystals have been obtained. At the Einstein "silver" mines, in Madison county, the rocks indicate an association of diorite and serpentine. The exact position and relation of the beds could not be ascertained, as all work had been suspended, but the specimens left include serpentine, green- and violet-colored fluor, clear and white quartz, argentiferous galena, wolfram, iron pyrites, and zinc-blende. The massive rocks near the river are red and gray granite, with red porphyry just west of them.

Only recently has much attention been directed to the quarrying of granite. There are but two quarries worked to any extent, the stone from which is used for paving streets and for general building purposes, principally in the city of Saint Louis. The stone from a quarry 4 miles west of Iron Mountain, Iron county, has been used in a pavement on Washington avenue, Saint Louis, for about 6 years, and the pavement is still in good order. The flagging around the Southern hotel, at Saint Louis, is also of this granite; also the front of the residence of Mr. Charles G. Stiefel. The amount of granite which may be obtained in this locality is practically inexhaustible. The eastern portion is a stratum of gray granite probably a mile in width. It has not been found farther north, but extends southwardly into Madison county for a distance of about 5 miles. The red or reddish-gray granite lies west of this, and is probably several miles in width, extending southwardly into Madison county, where it is wider in its east and west extension and more red in color. It extends south more than 10 miles, nearly to the mouth of the Little Saint Francis river.

The granite from the quarry at Knob Lick, Saint François county, is a coarse, feldspathic rock, made up of red feldspar and limpid quartz, with rarely a dark-colored bronze or black mica. It occasionally contains *lenticula* or ellipsoidal pockets of fine-grained, micaceous, gray granite, and these spots are often pyritiferous. Otherwise the quality of the rock on the whole seems good.

On the surface there are in several places large, rounded bowlders, some 20 feet high, resting on a small foundation, and some rocking-stones also occur. These large masses are roughly outlined and sent to market for building purposes. The smaller blocks are rough-dressed into 6-inch paving blocks and shipped to Saint Louis. Vertical joints sometimes occur, and a discoloration of 3 inches sometimes appears. One inch of the weathered crust occasionally crumbles off.

Feldspar has for several years been taken from the Sainte Genevieve quarries and used in glazing certain ironware.

Porphyries are often exposed in Madison, Iron, Wayne, Saint François, and Reynolds counties, and form the highest peaks in this region, being elevated from 200 to 660 feet above the valley. The foot of these mountains is

a A local term signifying that steep, rocky cliffs approach close to each bank of the stream.

generally flanked by porphyritic conglomerate, or limestone and sandstone of Potsdam age. The testimony of the rocks goes to show that previous to the formation of sandstone and limestone the country presented the appearance of rough porphyry knobs rising from 1,000 to 1,500 feet above the sea. In these depressions was the Potsdam sea, in its early ages quite tempestuous, as is evidenced by the conglomerates and coarse sandstone, chiefly formed of eroded fragments from the Archæan rocks. These sandstones occupied the shore-line of the Potsdam sea. In the course of time these waters became more quiet, and calcareous sediments with occasional sandy matter were formed: but observation shows that this deposit in no place extends along the Archæan slopes over 350 feet above the present valleys.

The porphyries, in their typical and most common form, seem to be a fine-grained, impalpable mixture of orthoclase and quartz, generally of a red, brownish, or purple color, sometimes dark gray or black, and porphyritic chiefly from the presence of feldspar crystals and often grains of crystallized quartz. Most of the porphyries on their edges show a shade of red; many of them are banded and show cleavage planes; in some we find well-marked lines of stratification, and some even show ripple marks, indicating a sedimentary origin. At Pilot Knob the porphyry incloses rounded pebbles, and epidote, hornblende, and serpentine occur; also beds and veins of specular iron represented on a large scale at Pilot Knob, Iron Mountain, and Sheppard mountain, some of the ore at the latter place being magnetic. Slate, resembling roofing slate in character, occurs on Buck mountain, in Iron county, and dikes of diorite and dolerite are sometimes seen.

At the so-called Tin mountain, in Madison county, the porphyry is traversed by coarse dioritic dikes and black dolerite, and on the waters of Captain's creek a dike of coarse syenitic greenstone, 75 feet in width, cuts the porphyry. In Sec. 16, T. 32, R. 6 E., there is an interesting exhibit of a series of dikes traversing dark porphyry (see Fig. 8 in *Missouri Geological Report*, 1874). Against the porphyry wall on the east are 10½ feet of greenstone, next west a few inches of dolerite, then 4 feet of porphyry, then 2 feet of greenstone, then porphyry. The course of the dike is S. 45° W.

In Iron county, in Sec. 9, T. 32, R. 4 E., a dike of hornblende rock, standing several feet above the general surface like a wall, can be traced north and south for one-eighth of a mile. On Gray's mountain, in Wayne county, and in the southeast part of Iron county we find exposed beds of steatite. In the northeast part of Reynolds county and the northern part of Madison county eruptive porphyry has been found of a gray color, and containing large crystals of white feldspar.

In Iron county are found amygdaloidal rocks flanked with porphyry. The amygdules are of a white mineral. A few miles southward the porphyry contains blue crystals.

A good exhibition of a dolerite dike in porphyry is on Mine La Motte property, at Jack diggings, and there is another dike at a cave on Rock creek. The porphyry is generally very hard and difficult to quarry.

SEDIMENTARY ROCKS.

A section of the unaltered Sedimentary in connection with the Archæan of southeast Missouri is about as follows:

1. Twenty feet of coarse, sometimes vitreous, sandstone, the second sandstone of Missouri geologists.
2. One hundred and twenty-five feet chert beds, with some clay and quartzite; contains *Murchisonia straparollus*, orthoceras, and a few species of trilobites, typical of the calciferous sand-rock.
3. One hundred to 300 feet of magnesian limestone, chert, and quartz, crystalized in drusy cavities; corresponds to the Third Magnesian limestone.
4. Magnesian limestone, 100 to 150 feet.
5. Fifty feet gritstone and lingula beds, to be referred to the Potsdam age.
6. Ozark marble, 5 to 50 feet.
7. Five to 90 feet sandstone and conglomerate.
8. Porphyry,
9. Granite, } Archæan.

The Lower Magnesian limestone, with the lingula beds just below, incloses the lead mines at Saint Joseph, in Saint François county, and also the mines at Mine La Motte. The galena is found with these rocks in horizontal beds between the layers of limestone, or occurs as a replacement of limestone beds, or is disseminated in the limestone; and these I regard as by far the richest lead deposits of the west.

The Third Magnesian limestone may be found over the greater part of 20 counties of Missouri, often forming mural escarpments along the streams, and sometimes extending to the highest hills. It is generally lead-bearing. It is both coarse and finely crystalline, and is often a pure dolomite of a bluish-gray or flesh color. It very rarely contains shale beds; but, especially in the upper part, there are some thick chert beds. At the lead mines of Washington county it is often cavernous, and includes numerous drusy cavities lined with minutely-crystallized quartz. At some of the mines, especially those of central Missouri, it has undergone a decomposition, and quantities of dolomitic sand are thrown out. It is well exposed along the Osage river from 10 miles above its mouth to the

line of Benton county; on the Gasconade from 20 miles above its mouth to its head, and on the two Pineys. It is seen on Osage river, first near Castle rock; passing up stream it gradually rises, and at the south line of Osage county it attains a thickness of 180 feet. It is often cavernous in the middle and lower beds, and sometimes forms natural bridges across streams. Many of the caves occur in this limestone, and saltpeter has been made from the clay deposits on the floor of the caves. Of note we might name Friede's cave, 10 miles northwest of Rolla. Other caves are found in Maries, Pulaski, Miller, Ozark, and in other counties of south Missouri. This formation also seems to be the source of many large springs in south Missouri, from which flow those bold, swift, clear streams, affording unsurpassed water-power. On the Osage, in Miller, Morgan, and Camden counties, the Third Magnesian limestone forms steep, mural escarpments and wild, picturesque scenery.

The second sandstone lies next above; it is generally coarse, whitish, or slightly brown, tinged by iron, occurring more often in thick beds, and affords a good building stone. It is often the top rock on the cherty hills of south Missouri; and the pineries, when found, generally grow here. It is also the formation containing most of the iron deposits of central Missouri.

The Second Magnesian limestone chiefly forms the Missouri bluffs from Saint Charles county to the west line of Cole county, often extending from the foot of the bluffs to their top. It contains very few beds suitable for building purposes, but the lower 25 feet are thickly bedded, some dolomitic, and with some intercalated beds of sandstone, affording a very good coarse building stone: for example, near Rolla, at Hermann, the Osage and Moreau, near Pacific railroad, at Jefferson City, and near Stoutland, in Camden county. But above these beds there is scarcely 1 foot in 50 feet of this formation suitable for building purposes. This is also occasionally lead-bearing. Most of the limestones in the upper half are readily acted on by frost. The middle and upper portions contain numerous green and drab shale beds, with many intercalations of concretionary chert, sometimes assuming curious grotesque forms.

The saccharoidal or first sandstone is found along the Mississippi hills from near Sainte Genevieve via Plattin creek, through Jefferson county, the western part of Saint Louis county, thence up the Missouri river, chiefly capping bluffs nearly as far west as Jefferson City. It is also pushed up to view on Sandy creek, in Lincoln county, near Auburn, and on the north line of Lincoln, west of Prairieville, and on Spencer creek, Ralls county, near the Saint Louis, Hannibal, and Keokuk railroad. It is generally a pure white sandstone, containing 99 per cent. of silica. It is well exposed at Crystal City glass-works, where it is used in the manufacture of fine plate-glass. At this place it is pure white and soft, and about 40 feet are exposed. At Pacific, Franklin county, it is well exposed for 100 feet, the upper 70 feet being a pure white soft sand; the lower part is tinged with oxide of iron. Due north of this, on the Missouri bluffs, Saint Charles county, it is 133 feet thick. Thirty miles east of this, or a few miles west of Saint Louis, borings reached it at 1,300 feet below the surface.

This sandstone is regarded as superior for glass-making, but it is often not sufficiently coherent for building purposes, though there are a few exceptions, namely, the stone used on the Missouri Pacific railway at Berger and between Hermann and Gasconade. Some quarries on the hills near by afford a beautiful pink-banded sandstone. Obscure fragments of a large species of orthoceras have been met with in Gasconade county, some of which measure 8 inches in diameter, others nearly 2 feet.

The First Magnesian limestone is found in Pike, Ralls, Lincoln, Saint Charles, Warren, Callaway, Boone, Franklin, Saint Louis, Pettis, Jefferson, Sainte Genevieve, and probably in a few other counties. Its greatest thickness is about 150 feet. It is generally easy to work, and forms a durable building stone of some beauty. Its prevailing colors are drab and buff. It caps the hills at Pacific, Franklin county. Missouri college, Warren county, is built of it, and very good quarries can be opened near by.

The Black River and Bird's-eye formation is probably found in Lincoln, Pike, Ralls, Saint Charles, Saint Louis, Warren, Franklin, Jefferson, Perry, Sainte Genevieve, and Cape Girardeau counties, but is wanting in central and southwestern Missouri. The upper beds are often full of winding vermiform cavities. The lower often have minute specks of calcite, and are likewise varied in color and would sometimes polish into a handsome marble. Such are found in Warren county on the hills near affluents to the Missouri, and are well exposed near heads of Tuque creek and Charette. The colors are drab, pink, purple, flesh-color, and buff. Another handsome variety found in Warren county has a brown appearance, with dark, almost black, winding lines, as of fucoids. Some of these would undoubtedly look handsome if polished, and are also durable. *Ormoceras tenuifolium* and other characteristic fossils have been found.

The Trenton beds, lying above the Black River beds, occur generally in thin layers of a bluish-drab color and may generally be found resting upon the Black River beds. At Danville, Missouri, and on Loutre river, near west line of Montgomery county, also at some places in the northern part of Lincoln county, it occurs whitish or else variegated, with many specks of calc spar disseminated, and appears very well when polished. The upper beds are almost entirely made up of numerous fossils, including *Orthis*, *Pleurotomaria Murchisonia*, with occasionally *Ceraurus pleurex anthemus*.

The Upper Trenton or Receptaculite limestone is found from Cape Girardeau, along the river counties, to Jefferson county, thence northwest to the town of Pacific and along the Missouri bluffs from Saint Charles county

to the eastern part of Warren county, thinning out westwardly. It is also found in Lincoln, Pike, and Ralls counties, resting on Trenton. It is quite cavernous in these counties, but in the counties on the Missouri and lower Mississippi it is a good building stone, and it also burns into an excellent quality of lime. The upper beds are brownish-gray, the lower a white, crystalline limestone. In Warren county the upper 20 feet is a light gray, the lower 8 feet a dark brown limestone. *Receptaculites Owcni* is everywhere found. We also find *Chætetes lycoperdon* and sometimes a trilobite. It corresponds in age with the Galena group of northern Illinois, but is not galeniferous in Missouri.

The Hudson River formation is found only in some of the counties on the Mississippi river. The beds are chiefly shaly, and are sometimes very pyritiferous. I regard this group as the source of most of the mineral springs of northeast Missouri. It affords some good flag-stone beds in Lincoln and Pike counties.

The Upper Silurian is best developed in Perry and Sainte Genevieve counties, where occur several hundred feet of drab and variegated limestone, which looks handsome when polished. In Pike county we find a drab and brownish limestone, sometimes in very thick beds, closely resembling the Grafton beds, and as useful for building purposes. We find this at Bowling Green, Paynesville, and between Frankfort and Louisiana. In Warren and Montgomery counties and the eastern part of Callaway county there are about 20 feet of a coarse, gray, crinoidal limestone, which is said to be a good "fire rock".

The Devonian is not of sufficient importance to take rank among building stones. It is best developed in Callaway county, where it affords many fine organic remains.

Sub-Carboniferous.—In the lowest, the Chouteau or Kinderhook group, we find at its base, at Louisiana, 55 feet of dove-colored, compact limestone, having a conchoidal fracture. This rock has every appearance of a lithographic limestone, and was so named by Professor Swallow. In other portions of the state the same limestone is represented by a thickly-bedded dolomite, and as such it is found on Sac river, in Cedar county, and at Taborville, in Saint Clair county.

Above this limestone are the vermicular sandstone and shales, characterized by winding, vermiform cavities from northeast to southwest Missouri. It is a friable, easily-worked sandstone, sometimes affording good beds for building purposes. The thickness, including the shale beds, is about 75 feet. Above this is the true Chouteau limestone, the upper beds of a coarse, gray, and sometimes ferruginous, crinoidal limestone, containing *Leptæna depressa* and *Spirifer marionensis;* below this is a thickly-bedded magnesian and sometimes argillaceous limestone, containing geodes of quartz and calcite and occasional chert beds. Where not too subject to frost action it affords a useful building material; as such it is found in Pike, Lincoln, Ralls, Boone, Callaway, Pettis, Cooper, and Greene counties. The lower part is formed chiefly of thin layers of dove colored limestone, which was seen 100 feet thick a few miles west of Sedalia.

The next above is the Burlington group, called by Professor Swallow the Encrinital. In Saint Charles county we find at the top about 17 feet of chert, with alternations of red clay. The middle beds are gray and coarse; the lower gray and brown, generally coarse and encrinital. Crinoid stems are commonly diffused throughout, the lower strata sometimes abounding in well-preserved *Crinoideæ*. This group is found at Burlington, Iowa, Quincy, Illinois, Louisiana, Missouri, and is well exposed on the Mississippi bluffs in counties north of Saint Louis, and from the western part of Saint Charles county, in remote hills, as far as Howard. It is occasionally met with in southwest Missouri, in Cedar, Dade, Greene, and Christian counties, where it is often cavernous, containing large and beautiful caves. The streams in Greene and Christian counties owe their origin chiefly to springs in this formation.

The upper beds of the Keokuk group are sometimes shaly, with geodes of quartz, and some of them are quite beautiful. The lower beds are gray and bluish-gray, with lenticular and concretionary chert beds. *Archimedes*, *Hemipronites crenistria*, and crinoid stems are numerous, and some fish teeth are found. This is the limestone of Keokuk, Iowa. It is found in the central part of Saint Charles county, in Saint Louis, Boone, Howard, Monroe, and Cooper counties, and is especially well developed in southwest Missouri, from Henry county southwest. It is the lead-bearing rock of Dade, Jasper, Cedar, Newton, and Lawrence, and is also found in McDonald and Barry counties. It is, in part, equivalent to the siliceous group of Tennessee, and is well developed in Benton county, Arkansas. It is probably 300 feet thick in its greatest thickness, and affords good quarries for building purposes. The Saint Louis group is best developed in Saint Louis and Saint Charles, and is also found in Lincoln, Lewis, Clark, and Knox counties. It is generally a compact, dove-colored, or finely-crystalline ash-gray limestone, with generally a splintery fracture. It is much finer grained than any other group of the sub-Carboniferous. It is also cavernous in Saint Louis, Saint Charles, and Lincoln counties, as shown by occasional funnel-shaped sink-holes which communicate with subterranean passages. The outlets of these sink-holes about Saint Louis have generally become filled, and ponds are the result. The characteristic fossils are *Melonites*, *Lithostrotion*, *Productus*, and *Hemipronites crenistria*, with numerous *Bryozoa*, with sometimes beautiful *Crinoideæ*. The lower or Warsaw division abounds in *Archimedes* and *Pentremites*.

The Chester group of 200 to 300 feet of limestone, with a sandstone, is found in Perry and Sainte Genevieve. The sandstone, often ferruginous, is found in northeast and southwest Missouri. Good quarries of this sandstone may be opened near Newtonia, Newton county; near Lamonte, Pettis county; in eastern and northern portions of Cedar and near Lamine, in Cooper county, and a very good quarry is worked near Sainte Genevieve.

The Coal Measures include the Upper Coal Measures (barren), 1,300 feet; Middle Coal Measures (productive), 320 feet; Lower Coal Measures (productive), 300 feet.

In Atchison there are exposed 180 feet of rock, including, at top, 40 feet of sandstone and red shale beds, with limestone and beds of calcareous shales below, containing well-preserved remains of mollusca, some of them presenting a strong Permian type. Below these are chiefly shale beds, with some limestone and occasionally sandstone, but with very little coal or even bituminous shale. There are thicker limestone beds in the Upper Measures than below, and they are also better for building purposes than those of the Middle and Lower Measures. Nevertheless some (especially the blue limestones) contain a good deal of pyrites, and are necessarily inferior. Those most suitable may be quarried at Kansas City, Jackson county, and in Cass, Clay, Platte, Andrew, Holt, Nodaway, Atchison, Daviess, Livingston, Mercer, and Harrison counties.

The middle series are chiefly sandstone, with some limestone beds and some coal beds of workable thickness, but rarely contain good beds of building stone. The Lower Coal Measures are the productive measures; they also contain beds of valuable sandstone for building, with numerous outcrops in southwest Missouri. Much of it is also suitable for making grindstones. The quarries near Miami station, in Carroll county, and near Meadville, Linn county, are the best in north Missouri, the others being inferior. In southwest Missouri most of the sandstones are bituminous.

Recapitulating, we would briefly say that the granite of southeast Missouri is the best material for building purposes. The pure limestones are generally of good quality. But few of those of the Upper Carboniferous are durable, nor are many of the beds of the Second Magnesian limestone. The sandstones are most eagerly sought after, chiefly because they are easy to quarry and to work into shape. They also answer better for city work. The best include the Potsdam of southeast Missouri, found in Madison, Saint François, and Iron counties. Others may include the sub-Carboniferous of Sainte Genevieve, Newton, Cedar, Pettis, Howard, and Cooper counties; also, the sandstones of the Carboniferous, found among the Lower Coal Measures of southwest Missouri, chiefly in Barton, Vernon, Cedar, Saint Clair, Henry, Johnson, and Carroll counties. The second sandstone along the Osage and on hills of southwest Missouri is also a good building stone.

Saint Louis quarries.—The most extensive limestone quarries in this state are located in and near the city of Saint Louis. The formation is the Saint Louis division of the sub-Carboniferous period. The extent of the quarry industry in this locality is not so much due to the superiority of the stone as to its accessibility to the Saint Louis market. A representative section of the quarries is shown at Mr. Moran's quarry, which shows 20 feet of loose material; 20 feet of thin, shelly limestone, in layers from 3 to 8 inches in thickness; 3 feet of brownish-colored limestone, containing some chert. From this quarry a specimen of *Productus marginicinctus*, a very rare fossil peculiar to this group, has been obtained.

The stone from this quarry is used for the construction of foundations and other ordinary building purposes, and for street pavements, especially for macadam. The stone from the best Saint Louis quarries is strong and durable, and is also well adapted to the manufacture of lime. Its principal use has been in the construction of foundations. The excavation has been carried at one quarry to a depth of 60 feet, but at present the quarry is not worked to a greater depth than 40 feet, 20 feet of the lower portion of the excavation being filled with water. A section at this quarry shows 8 feet of cap-rock; 8 feet of limestone in thin layers; 9 feet of limestone in layers 12, 4, and 2 inches thick, and below this a massive, heavy bed of limestone; still lower the beds are from 1 foot to 2 feet thick, this being the most applicable for building purposes. The quarry of Mr. Philip Steifel has become somewhat noted for its fine mineral specimens, including calcite, pearl-spar, dog-tooth spar, millerite, and fluor-spar. The fluor-spar is of a yellow color; the calcite is white, or colored on the outside with millerite. In some places the limestone has a greenish tint from the presence of nickel-sulphide. The millerite has bunches of stray hair-like crystals of a bronze color, and each crystal is a delicate hair-like mineral. It has been found penetrating the calcite and extending from side to side in the limestone. It is also frequently found associated with the pearl-spar.

Among the most valuable of these quarries as regards the quality of the material are three at Cote Brilliant, about 2½ miles from the city of Saint Louis. Its development is only retarded by its being at a greater distance from the market than many of the other quarries.

A section at one of these quarries shows 25 feet of loose material; 15 feet of gray limestone, in layers about 3 inches in thickness; 4 feet of limestone, in layers of variable thickness; 2 feet of close grained gray limestone; five 3-inch layers of gray limestone; one 22 inch layer of gray limestone; and 15 feet of limestone below the water level.

The best layers are pure limestone, susceptible of being quite highly polished, very strong and durable, and quite well adapted for architectural purposes.

The formation in the quarry of Mr. Gottlieb Eyerman probably belongs to the upper portion of the Saint Louis group, though it may belong to the next higher, the Chester group.

Jefferson City quarry.—The greater part of the quarry product is used at present by the Missouri Pacific Railroad Company for the construction of bridges; the small fragments are used for ballast, and small slabs are sold to citizens of Jefferson City for ordinary building purposes.

The following is a section at this quarry:

1. Soil and clay	6 feet.
2. Unevenly-bedded limestone and chert, in thin beds, suitable for ballast only	12 feet.
3. Fine-grained homogeneous rock, in even thin layers, locally called "cotton rock"	4 feet.
4. Gray limestone with numerous small cells filled with white powder	2 feet.
5. Chert beds	2 feet 6 inches.
6. Drab, evenly-bedded limestone, also called cotton rock	9 feet.
7. Gray, hard, cellular limestone, generally preferred for bridge construction	10 feet.

No. 6 is similar to the rock which was used in the construction of the state-house, which was erected about forty years ago. It is occasionally slightly discolored with stains of iron, of which minute globules and specks are seen, apparently changed from pyrites. The layers from this rock are of quite uniform thickness, many of the 4- and 6-inch layers making a very handsome paving stone. It has been quite extensively used in Jefferson City, where it has been termed cotton rock, by which name it is also known in other localities in this state. The prevailing color of this rock is drab, but in some localities it has a bluish tint, and is liable to disintegrate rapidly on exposure to the action of frost. Some of the drab layers also readily disintegrate on exposure to the weather. The best of the material needs to be quarried early enough in the season to allow the quarry water to become dried out before the stone is exposed to the action of frost.

No. 7 is a harder rock, and is not well adapted for cut work, though a very desirable material for heavy bridge construction, for which little dressing is necessary, and for which the qualities most desirable are those of strength and durability. The rocks at Jefferson City may all be referred to the Calciferous sand-rock group, known in Missouri as the Second Magnesian limestone series. Fossils are very rarely found. A section of 200 feet may be seen at Jefferson, and only a *lingula* is found in the upper beds; the other beds abound in fucoids. Lime manufactured from some of the layers possesses hydraulic properties.

BOONVILLE QUARRY is located on the bluff side of the Missouri river, just above the railroad bridge, and about 12 feet above the ordinary water-level in the river. When the river rises to the level of the quarry operations are necessarily suspended. The bluff rises steeply above the quarry for over 100 feet, so that the quarry cannot advance far inward on account of the rapidly-increasing amount of cap-rock. The layers of stone are generally tolerably even, and from 10 to 16 inches in thickness, with occasional partings of calcareous shale. A vertical section of quarry rock 16 feet in thickness is exposed. The strata dip slightly to the west. A little to the east, at the bridge, about 30 feet of gray, cherty limestone are exposed, containing, as far as could be seen, only specimens of an *Archinedipora* and a turbinated coral. The quarry rock lying above this also contains specimens of *Archimedes*.

SEDALIA QUARRY.—The product of this quarry is used locally for foundations. The strata quarried lie at the junction of the Chouteau or Kinderhook group with the Burlington beds. The following is a section of the quarry:

Loose material	5 feet.
Gray ferruginous limestone, in two layers	5 feet.
Buff limestone, shading to blue below	3 feet.
Shales	1 to 3 feet.
Blue limestone, with chert concretions and some masses of calcite	5 feet.

The floor of the quarry rests on a rock similar to the lowest which has been quarried. The lowest beds are the least durable, the upper 5 feet of limestone being quite durable. These two layers belong to the Burlington group, and the beds below them to the Chouteau.

A number of small quarries have been worked in this vicinity. From some of these blocks 4 feet thick may be obtained, all, however, containing more or less chert concretions and masses of calcite. One of the older quarries shows much of the rock shattered by frost.

CLINTON QUARRY is located about 4 miles south of Clinton, Henry county. It furnishes material to the town of Clinton, principally for sidewalk pavements. The stone is an argillaceous limestone, and occurs in a stratum about 15 feet in thickness, and in layers from 2 to 10 inches in thickness. The thinner layers are drab-colored throughout; the heavier layers have a lead-blue color in the interior, and those layers which have not been exposed to atmospheric action also have the lead-blue color. Below this quarry rock occurs a seam of bituminous coal 4 feet in thickness, which is one of the best coals of southwest Missouri. Below this again there are 9 feet of blue shales, with ironstone concretions to the level of the water in Grand river. Similar beds occur near Brownsville, Sabine county, and may be referred to the same geological age.

KANSAS CITY QUARRIES.—The stratum of limestone designated in the *Missouri Geological Reports* as "No. 87, general section, Upper Coal Measures", has been quarried extensively at quarries in bluffs of Kansas City and for 2 miles further east; also in a quarry opposite the Union depot, Kansas City, now abandoned on account of expense of stripping. The rock is also occasionally quarried in bluffs at and above Rosedale. Its color is generally a light gray, becoming locally a bluish-gray, and, when exposed, a lighter and often ferruginous gray. The middle portion of about 9 feet is beautifully oolitic, and is most valuable for building; it works freely and is easily dressed.

Below Kansas City the stripping at first is only a few feet, but of course increases as the operations extend into the bluffs.

Limestone No. 90, Upper Coal Measures, lying a little above, is often quarried and used for ordinary foundation work, while the limestone under consideration is used for general building purposes. It may be seen in the basement walls of the Merchants' exchange, the *Journal* office, and the building at Twelfth and Washington streets, Kansas City. It contains the characteristic coral *Campophyllum torquium* (O. and S.). It is generally evenly bedded in layers from 6 to 16 inches in thickness, and is much used in foundations. It is apparently durable and of more than usual strength. Its texture is homogeneous, and often has numerously-disseminated bright calc-spar specks. The color in the quarry is a grayish-drab, weathering to a brownish-drab, and shows a brownish discoloration along the joints.

Limestone No. 96, of Upper Coal Measures, also found here, is a bright gray rock with numerous specks and short lines of calcite. It contains also many fossils whose shells are of pure calcite, or else the interior is nicely crystallized. The strata are generally from 6 to 9 inches thick and of very irregular bedding. The entire stratum is 30 feet thick. An examination of the various quarries in Kansas City indicates that about 50,000 cubic yards of rock have been removed and used in the city during the past twelve or fourteen years. This includes from 9,000 to 10,000 cubic yards from the bluff opposite the Union depot, 30,000 cubic yards from southwes Kansas, and the remainder from south Kansas. The various railroads have probably taken out and used 10,000 cubic yards not included in the above.

There is quite a number of localities in Missouri where limestone has been quarried or may be quarried, beside those in which there are actually working quarries as represented in the tables. Three miles north of Canton, Saint Louis county, the Central Marble and Stone Company has recently opened a quarry in the sub-Carboniferous formation. The beds vary in thickness from a few inches to 8 feet. Considerable quantities of this stone have been quarried for bridge abutments, foundations, and for flagging. The stone has a uniform texture and gray color, but becomes darker on exposure to the atmosphere; and this may prove a defect if the discoloration does not go on uniformly. The quarries are located less than half a mile from the Saint Louis and Keokuk railroad and one mile from the Mississippi river.

Near Bowling Green, Pike county, the Niagara limestone has been quarried in a small way for the past forty years, and has been quite largely used for bridge abutments on the Chicago and Alton railroad, and occasionally for the construction of buildings. A dwelling in Bowling Green, built about forty years ago, is of this material, and the stone still looks well and shows no signs of disintegration. There are two quarries. A section at one quarry shows 4 feet of soil and gravel, 4 feet of shelly limestone, and 12 feet of building stone in three layers, the upper of which is 2 feet in thickness, and the two lower each 5 feet thick. This stratum of building stone is separated from a stratum of equal thickness below by 1 foot of shales. This last stratum of building stone consists also of three layers, 4, 6, and 2 feet in thickness. At the other quarry about 40 feet of rock are exposed in layers from 1 foot to to 2 feet in thickness. The stone when first quarried has a bluish-gray color and weathers to a brownish-buff color.

Near Glencoe, Saint Louis county, the Trenton limestone has in former years been quarried for building purposes. There are at present quite extensive quarries still in operation, but their product is all manufactured into lime. At Cape Girardeau, Cape Girardeau county, is quarried the Lower Silurian limestone, most of the material being burned, and that which is most suitable being reserved for purposes of construction. At present some of this stone is being shipped for repairing the state capitol of Louisiana, which was built of this stone, and was partly destroyed during the late war. The quarry is situated about three-quarters of a mile from the wharf, on the Mississippi river, and the stone was at one time quite largely shipped to the south. An analysis of this rock by Dr. A. Litton, for the *Missouri Geological Report*, gave carbonate of lime, 99.57; silica, a trace; alumina, a trace.

The total thickness of rock exposed at the quarry is about 30 feet, the upper portion being in thinner layers and a little darker in color than the lower. The lower portion is a beautiful white limestone, and blocks 6 feet in thickness could be obtained.

Near Rolla, Phelps county, quarrying has been done in a small way in the lower portion of the Second Magnesian limestone. This stone has been used for the construction of culverts and bridge abutments, and near the same place a thinly-bedded, hard, and durable limestone occurs which has been used for sidewalks.

Some of the limestones in southeast Missouri have been called marbles. The Cape Girardeau limestone has been termed a marble by some. In the *Kansas City Review of Science and Industry* the marbles of southeast Missouri are described; and it is given as the reason why these marbles have not been extensively developed, that they usually occur in beds not of sufficient thickness to furnish blocks of adequate size for the purposes for which marbles are usually employed. It states that near the head of Cedar creek there are several outcrops of variegated red and drab marbles. A section of rocks on a southeastern branch of Cedar creek shows 10 feet of coarse magnesian limestone resting on 10 feet of light drab marble of fine grain traversed with brown veins. Near the mouth of Cedar creek, Madison county, some of the finest exposures of the most handsome varieties of marble occur. It is handsome when polished, and the outcrops show that it is very durable. At the head of Tom Suck creek, in Reynolds county, are thick beds of flesh-colored marble. Two miles north of Cape Girardeau, on the land of Dr. Thomas Holcombe, are outcrops of variegated purplish-red limestones, with occasional calcite specks in heavy layers. Marbles of fine texture passing through various shades of flesh color, yellow and green, pink, purple, and chocolate, all handsomely blended, are said to occur in Sainte Genevieve county. These marbles occur

in the Potsdam and Niagara formations. The Potsdam marbles are found on Stout's creek and Marble creek, in Iron county; Cedar creek, Marble creek, and Leatherwood creek, in Madison county; and Tom Suck creek in Reynolds county. The Niagara marbles are found in Cape Girardeau and Saint Genevieve counties.

Near Mooresville, Livingston county, limestone in the lower portion of the Upper Coal Measures has been quarried since 1866, but the quarries have not been regularly worked. A section there shows 1 foot of soil, 4 feet of shelly limetone, 2 feet of clay shale, 1 foot of bituminous shales, 6 inches of clay shales, from 2 to 3 feet of blue fire-clay, and 9 feet of oolitic limestone valuable for building purposes. The rock is rather hard, quite strong and durable, and is especially applicable for heavy masonry. This same formation has also been quarried in hills 5 miles south of Princeton, Mercer county, near the line of the Chicago, Rock Island, and Pacific railway; also on the Wabash, Saint Louis, and Pacific railway, Clay county, about 8 miles from Kansas City. It may also be found near the base of the bluffs at Kansas City, and at several places near Pleasant Hill, Cass county, where it is locally termed cotton rock, and is said to withstand a higher degree of heat than many other limestones.

At Forest City, Holt county, there are several limestone beds exposed, and also a soft sandstone, but the stripping is generally so heavy that the best layers of the rock cannot be extracted with profit. Limestone also crops out 2 miles above Forest City, and beyond this for 20 miles no building stone occurs.

Near Amazonia, Andrew county, 14½ feet of evenly-bedded, ferruginous gray, and somewhat oolitic limestone occurs. A quarry of this rock was formerly worked 2½ miles northeast of Savannah, and the stone was transported by wagons to Saint Joseph and used in the construction of buildings. Similar quarries might be opened near the line between Andrew and Buchanan counties, and the same formation also crops out near Atchison, Kansas.

Near Greenwood, Jackson county, the Missouri Pacific Railroad Company has opened a quarry, but the material is used principally for ballast, and only a small amount has been used for the construction of culverts. Oolitic limestone of the Upper Coal Measures has also been found near Greenwood, and is used for purposes of construction on the Missouri Pacific railroad. The stone is well adapted for rough masonry.

Near Pleasant Hill, Cass county, there are several quarries situated in different localities which have occasionally been worked. The stone has been used principally for the construction of railroad bridges and culverts, and for local purposes. The formation belongs to the Upper Coal Measures, and consists of a number of limestone beds, some of which are oolitic and some shelly. Blocks 2 feet in thickness and of any length and breadth desired may be obtained.

At Neosho, Newton county, a whitish-gray oolitic limestone is quarried for lime. This stone works freely, and would be well adapted for purposes of construction. A coarse, dark gray limestone is also quarried near Neosho, some of which contains many chert concretions.

The sub-Carboniferous limestone has been quarried for local use at Springfield, Greene county. The quarry rock shows a face of 10 feet in depth of coarse, gray limestone. The upper beds resemble the Keokuk limestone, and the lower beds are more of the Burlington type. The geological divisions recognized in Iowa, Illinois, and eastern Missouri cannot strictly be sustained in southwest Missouri.

The Second Magnesian limestone has been quarried near Marshfield, Webster county. The exposure shows one bed 33 inches in thickness of buff limestone. This appears to be a durable stone, easy to quarry and to dress. It is covered with but little cap-rock, but the stripping would be slightly increased as the excavations would be extended into the hill. There are two good exposures a few hundred feet apart.

QUARRIES OF SANDSTONE.—At a quarry located 1½ miles west of Miami station, Carroll county, there are two grades of material produced. The poorest quality contains many plant remains, and shows dark lines of fragments of plants, along which it is often fractured by frost. The best quality is free from these defects, and is a rather beautiful gray sandstone. There is a vertical face of about 70 feet exposed, the lower 45 feet being without any seam of bedding, but containing occasional concretionary masses of harder sandstone. At the top there is a depth of about 6 feet of soil and clay, and below this are 20 feet of rough and sometimes shelly sandstone layers. The quarry rock is a rather coarse, gritty, sandstone, making an excellent building stone, and being also valuable for the manufacture of grindstones. The concretionary masses are of no value whatever. They have some argillaceous layers interstratified, and also contain many nice fragments of plant remains. Although there seem to be no bedding planes in the lower 45 feet, still there are a few faint, banded, dark carbonaceous streaks occurring from 6 to 12 feet apart. The absolute percentage of waste material embraced in the concretionary masses amounts to about one-fiftieth of the entire mass. The concretionary portions disintegrate quite rapidly on exposure to the weather, but the other material is very durable. This quarry has been actively worked for about fifteen years, and the rock has been shipped to various markets in Missouri, Kansas, Iowa, and Nebraska. Eastwardly along the bluffs the rock has a more brown color, and is not so highly esteemed.

The Warrensburg quarries are of the same geological age as the above. At the quarry of Messrs. Bruce & Veitch the rock when quarried often shows planes of cross lamination, and this, although otherwise of good quality, is not of sufficient value for shipping purposes, but is used locally for ordinary purposes of construction. Considerable loss results from this defect. The planes of these lamina are separated by carbonaceous matter. The stone in this quarry is quite soft when first taken out, and hardens on exposure. Various openings have been made in this vicinity which are not now worked. From one of these 6,000 cubic yards were excavated, and

from another 500 cubic yards. Three-quarters of a mile northwest, on the land of Mr. Bunn, a coarser sandstone of the same geological age appears, about 20 feet in thickness, forming a solid bluff on the Blackwater for several hundred yards, and seems to underlie an area of about 10 acres.

Quarries 2 miles north of Warrensburg occupy a tract of probably over 200 acres in sandstone of the Lower Coal Measures. The total thickness of this sandstone is over 100 feet. The quarries have not developed the entire thickness suitable for building purposes, only 45 feet in depth having been quarried.

The sandstone hills are bounded on the north by Blackwater river, on the west by Post Oak creek, and on the east by Potts branch. Approaching Warrensburg from the north we still find sandstone, but of an inferior quality. In the railroad cuts and southward, and throughout the town, and for a short distance north, the rock is generally brown and soft, and crumbles to powder on exposure. It also sometimes alternates with shaly beds, and sometimes incloses beds of ferruginous conglomerate, and but rarely is it suitable for building purposes.

Northwardly, as we approach the quarries, the rock is more homogeneous, the color becomes a light gray, and bluish-gray in deeper quarries. Concretionary masses of a harder sandstone not easy to work, in fact worthless for shipping, sometimes occur. These contain many carbonaceous stains and fragments of calamites and other plants. A trunk measuring over 1 foot in diameter, with its bark half an inch in thickness changed to bituminous coal, was taken out. It is supposed to belong to a coniferous tree, probably *Dadoxylon acadicum* of Dawson.

North of the Blackwater good quarries have also been opened, and over thirty years ago columns for the court-house at Lexington, Missouri, were cut out. Those columns are still entire, and are discolored only by time.

The Normal School building at Warrensburg was the first structure of note in which this stone was used, but since then it has been largely shipped to many places, including Saint Joseph, Kansas City, and Saint Louis, Missouri; also Chicago, Illinois, and Lincoln, Nebraska.

In 1871 the quarries were opened, and in 1874 one firm shipped 900 car-loads over the Missouri Pacific railway. A block 20 by 6 by 2½ feet was taken out and used in the Chamber of Commerce building at Saint Louis. The rock weighs 140 pounds to a cubic foot when dry, but only from 145 to 150 pounds when first quarried. It forms a large proportion of the face-stone of some Saint Louis dwellings, and it was also used in the Union Depot building at Chicago. It stands the test of time very well. It is not known to have scaled off, but after long exposure it becomes darker on the surface and somewhat stained.

The Miami and Warrensburg quarries are systematically worked by means of channeling and wedging. No powder is used except for removing the cap-rock.

A quarry in Clinton, Henry county, furnishes stone for ordinary construction for local use. A section of the quarry shows 3 feet of loose material, 4 feet of sandstone in layers from 1 inch to 4 inches in thickness, and below this 7 to 8 feet of sandstone in layers from 2 to 3 feet in thickness.

The Sainte Genevieve quarry is located about 1½ miles from the Mississippi river, which furnishes the means of transportation. Blocks of the largest size desired can be obtained at this quarry. Pieces 150 feet long, 20 feet wide, and 10 feet thick are often channeled off and loosened with the wedges.

The Insurance building at Sixth and Locust streets, Saint Louis, was chiefly built of this stone, including the figures on the top. The stone has been much tarnished by the smoke of the city. Among the other structures of this material are the Singer Sewing Machine building in Saint Louis, the approaches to the Saint Louis bridge, the arsenal at Rock Island, Illinois, and the state capitol of Iowa. Everywhere the stone has proven very durable. The quarry shows 25 feet in thickness of good uniform rock; the layers, 1½ to 5 feet thick, can be split readily into thin slabs if required. It is occasionally false-bedded, and then contains fragments of plant remains, chiefly carbonized. The thin layers are very much ripple-marked and the texture of the rock is generally homogeneous. It is soft when first quarried and hardens on exposure. It is a good fine grit, and a number of grindstones have been made of it.

The geological age of the formation is the Chester group of the sub-Carboniferous. The bluffs near by show about 25 feet of gray limestone of the Saint Louis group lying below it.

KANSAS.

GEOLOGICAL SECTION.

			Feet.
1	Tertiary	Pliocene sandstone	150
2	Cretaceous	Niobrara	200
		Fort Benton	260
		Dakota	500
3	Permian	Limestone and shales	1,000
4	Carboniferous	Upper Coal Measures: Limestone, shale, and sandstone	1,300
		Middle Coal Measures: Shales, coal, sandstone, and limestone	370
		Lower Coal Measures: Sandstone, limestone, shale, and coal	350
		Sub-Carboniferous limestone	150

GENERAL DESCRIPTION.

SUB-CARBONIFEROUS.—The sub-Carboniferous occupies a very limited area in the southeast corner of the state, but is highly galeniferous, as the lead mines in southeast Kansas occur in this formation.

CARBONIFEROUS.—The Carboniferous, as developed in the Lower Coal Measures of southeast Kansas, incloses some thick and valuable coal beds. It also includes many beds of sandstone of an excellent quality for building purposes and good flag-stones. These may be found of good quality and well exposed in Cherokee, Crawford, Bourbon, Neosho, Labette, Montgomery, Wilson, Woodson, Greene, and Elk counties.

The Middle Coal Measures include several good beds of workable coal, and coal has been mined at Oswego, Fort Scott, Thayer, and near Toronto, and in Osage county. In Bourbon and Linn counties we find several thick limestone beds, but the western outcrops in Greenwood county are chiefly of sandstone.

The Upper Coal Measures in northeast Kansas include a number of limestone beds, with a good deal of shale and some sandstone, but in southern Kansas we find but few beds of limestone, nor do the Upper Coal Measures include many strata desirable for building purposes.

The Permian is made up of beds of drab-blue shales, with occasional limestone strata. In the lower series we find many excellent beds of rock for building purposes; some of the strata are slightly magnesian. The middle beds are now very much worked; in fact quarries are now opened and successfully worked upon all the lines of railroad where this rock is found. The character of the rock does not materially differ in the various quarries, whether in northern, central, or southern Kansas. The building stone of the lower strata is not so soft as that higher in the series. The color is always the same shade of drab or buff. The beds are all softer than those of Carboniferous age; and, being at the same time durable, they are much sought after by builders. While I call these rocks Permian, I must say that the contained fossils have also been obtained from the Upper Carboniferous of Missouri and Kansas; in fact, I believe nearly every well-known Permian fossil of Kansas has also been obtained from the known Upper Carboniferous strata of Kansas City, Missouri. Lithologically the rocks seem different, and we have mostly to be guided by their general appearance, which is very easily recognized even in small specimens.

CRETACEOUS.—The Dakota group is easily recognized, it being composed entirely of sandstone or shales. The sandstones are sometimes of a dirty white color, but are more often a ferruginous brown. Good specimens of fossil leaves of dicotyledonous plants are sometimes found; also occasional layers of clay, ironstone, and some thin deposits of a poor quality of coal.

The Fort Benton group in the lower part consists of dark shales, with beds of brown limestone in the upper part, which are very much used for building purposes. Although this rock is very soft, it is otherwise very durable and strong enough for buildings of several stories in height. One bed, banded red or brown and buff-brown, I have traced from Mitchell county through Russell and Ellsworth counties to Rush county. It is easily wrought with a common saw, and forms handsome walls, but is too soft for sidewalks.

The Niobrara group of western Kansas affords the white-chalk beds, which furnish a very handsome white stone, but it is too soft for many purposes. It is extensively developed in western Kansas. This formation contains many rare and interesting remains of extinct vertebrata. The Tertiary is confined to northwest Kansas.

The building stones of Kansas, although extensively used, are much softer than those of the states east, but, being easily worked, are being used now in many cities. Most of the Permian strata are too cellular or porous.

QUARRIES.—The stone quarried near Irving is used at Atchison, Kansas City, and on the line of the Union Pacific railroad, which passes at a distance of about half a mile from the quarry. The rock is quarried for a distance of three-quarters of a mile in the bluffs south of the railroad. The upper or western quarry is from 15 to 20 feet above the valley; the lower quarry is from 30 to 40 feet above it. The outer rock is blasted off and used for ballast on the railroad. After the stripping is taken off a level floor is sometimes exposed from 20 to 30 feet wide, and extending several hundred feet along the hill. The limestone formation quarried here is of no great thickness. At the upper quarry there are 3 feet of shales and soil, and below this three layers of limestone, the first 8 inches in thickness and the other two each 13 inches in thickness. At the lower quarry there is 1 foot of soil, and below this are four layers of limestone 9, 12, 16, and 19 inches in thickness, respectively, the last sometimes divided into two layers. The stone is quite soft and easily quarried, and is also easily dressed when first taken out, but hardens on exposure. The strata are very nearly horizontal and the beds are of quite uniform thickness. For the construction of railroad bridges and other like structures the stone requires but little dressing.

From a quarry on the hill-top 1 mile southwest of Frankfort the stone is used principally for foundations, though a church and a school-house and some storehouses have been constructed of it. There are other small openings both to the east and to the west of it. The hill is about 150 feet high, and the quarry rock occurs near the summit, with shales below, while a good bed of building stone appears near the base of the hill. The beds here worked are apparently the same as those quarried near Irving, and dip to the west from 80 to 100 feet in 7 miles.

The Atchison quarry furnishes stone for ordinary building purposes for local consumption. The limestone is here only from 4 to 8 feet in thickness. Sometimes it is cross-laminated, when it can only be used for common purposes. The bedding is generally even and horizontal.

Stone near Manhattan is quarried chiefly on the hill-top, about 200 feet above the valley of the Kansas river. A large portion of that used for the superstructure of buildings is taken out about 30 feet below the summit of the hill. A section of the rocks here is about as follows: Soil, 1 foot; limestone for bridge construction, 16 inches; limestone, 11 inches; flag stone, 4 inches; two layers of limestone, 12 and 14 inches; depth not exposed, 30 feet; shaly, bluish limestone, 2 feet; building stone, 1 foot; and dark shale to the base of the hill, 170 feet, with a few limestone beds and red shale about half-way down.

The stone used for bridge masonry is cellular and coarser than the other, but is equally strong and durable. Of the stone from these quarries there have been constructed in Manhattan an addition to the college building, six churches, the Adams hotel, and several fine residences.

There are about 35 common buildings in Topeka built from the stone from a neighboring quarry. They are all roughly built and laid in mortar. Some buildings have brick fronts, with stone in the remainder of the superstructure. This stone is also used in foundations. From another quarry the stone is shipped to various points along the Missouri Pacific railroad in Kansas and Missouri. This stone was used in the construction of the Congregational church and the public-school building at Emporia, Kansas, and an opera house is now being constructed of it in the same town. The Missouri Pacific Railroad Company has selected this material for the construction of shops, one about to be built at Parsons, Kansas, and another at Sedalia, Missouri.

The stone from a quarry near Lane, Franklin county, is used principally at Ottawa and at Garnett, and some has been shipped to Chicago. One of the buildings of the asylum for the insane at Osawatomie was built of this stone. There are two varieties of stone obtained at this quarry, one a little darker in color than the other, and more uniform and compact in texture. The darker-colored variety has been dressed and sent into the markets for several years under the name of "coralline" limestone. It is sometimes called oolitic limestone, being largely composed of small fossil fragments very much like the Indiana oolitic limestone and having also a similar appearance. This variety has a very firm, compact structure, and is susceptible of being quite highly polished. In the lighter colored variety the fossil fragments are many of them larger and not so uniform in size, showing some evidence of stratification in alternate layers of coarser and finer material; and the interspaces between the fossil fragments are not well filled, giving the stone a rather open and vesicular structure. This stone being easily quarried and dressed, is quite extensively used for buildings and trimmings. The quarry which is here most largely worked is on the point of a bluff about 100 feet in height. A branch of the Missouri Pacific railroad passes along the base of the hill, and provision might easily be made by which the stone could be placed on a car at the quarry, but at the present time it is drawn a distance of 1 mile to the station. A section of the quarry shows the following: Loose material, 4 feet; vesicular buff limestone, one layer 4 feet in thickness and another 1 foot in thickness; gray, irregularly-stratified limestone with some chert connections in layers from 2 to 6 inches in thickness, 6 feet; blue shale in thin laminæ, 1 foot; irregular layers of buff limestone, 2 feet; gray limestone, 4 feet; and bluish-gray or drab oolitic limestone, 6 feet. This last has lately been most extensively used for building purposes. The layers are from 18 to 24 inches in thickness. These beds are all referred to the upper portion of the Carboniferous period. They are also well exposed along the bluffs of Pottawatomie creek from near Lane to Garnett. The upper quarry rock has been quarried at Greeley on the hill-top and used in railroad masonry. It has also been quarried near the Lawrence and Southern railroad, north of Garnett, and appears in the Marais des Cygnes bluffs near Ottawa for a distance of 15 miles to the east. Good specimens of fossils can sometimes be obtained from this formation.

The geological age of the formation in which the Cottonwood quarries are located is probably the middle or upper part of the lower beds of the Permian period. The rocks here lie below those quarried at Marion Center and Florence, and are probably above the Dunlap stone. Blocks of any length and breadth desired, and 2½ feet thick, can be obtained from these beds. The quarries are easily worked by channeling and wedging. The stratum of quarry rock is, however, only about 6 feet in thickness, overlaid by a few feet of thin limestone layers and shales. The stone is used for general building purposes at Kansas City, Saint Joseph, Omaha, Des Moines, Pueblo, Denver, Lincoln, Atchison, Leavenworth, and Topeka. The material may be seen in the west wing of the state-house and in the basement of the post-office at Topeka; in the basement of the depot at Pueblo; in the court house at Leavenworth; in Creighton college at Omaha; in the depot at Atchison; in the Missouri Valley Life Insurance building at Leavenworth; and in numerous other buildings along the line of the Atchison, Topeka, and Santa Fe railway.

The beds quarried at Marion Center belong to the Middle Permian, and are at a horizon above those quarried at Cottonwood station, as has already been stated. A general section here shows: Flag stone layers from 2 to 6 inches in thickness, 5 feet; magnesian limestone, 16 inches; yellowish drab soft limestone, uniform in texture, easily dressed, and used for the construction of buildings, 23 inches; and drab colored limestone, considerably fractured and containing numerous chert concretions, 20 feet. The material from this quarry has been used in the construction of the asylum for the blind at Wyandotte, and the asylum for the insane at Topeka.

The Florence quarry is now worked only to a small extent for flagging, and occasionally some building stone is taken out. Most of the stone quarried is manufactured into lime and cement, the lower beds being used for lime. The excavations extend along the side of a hill for a distance of about 1,000 feet. A section here shows: Local drift, 4 feet; drab limestone in thin layers used chiefly for lime, including also flag-stone layers and some stone which has been used for purposes of construction, 14 feet; below this are 6 feet of rough layers of limestone; 2 feet

of yellow shales; and 6 feet of rough limestone, sometimes apparently in two layers, with occasional cavities sometimes 2 inches in diameter. These strata are evidently equivalent to those at Cottonwood station, all of well-known Permian type, with typical Upper Carboniferous fossils. This stone was used in the construction of a sugar factory at Sterling, Rice county, and of a church at Topeka.

The formation quarried at Augusta probably belongs to the Upper Permian beds. The quarry rock lies at the base of a hill and includes 6 feet of soft, buff-colored limestone in layers 1 foot and 2 feet in thickness. A few feet higher in the hill flag-stone layers occur 2, 6, and 8 inches in thickness. This stone is a little harder than the building-stone rock, and is used principally for sidewalks. Another building-stone quarry has been opened 1½ miles south of Augusta, where the rock presents a favorable appearance. Although quite soft, the stone is sufficiently strong for all ordinary structures and is quite durable. It has been used in the construction of some stone buildings at Augusta and at Wichita. Its largest use is perhaps for foundations and trimmings.

There are probably a half dozen irregularly-worked quarries of the same kind of stone around and in Fort Scott. It is locally used for buildings, walls, foundations, and also for pavements. There are several houses built of it, and it stands the wear of from ten to fifteen years exposure very well. It turns to a brownish color on long exposure, and it possesses all the strength required for common structures. The layers are generally separated by thin, brown, calcareous, shaly bands, often containing fragments of *Crinoidea* and other known Carboniferous fossils.

The following is a general section of Fort Scott strata: Limestone, 4 feet; calcareous shales, 1 foot; bituminous shale, 4 feet; coal, 8 inches; shales and fire-clay, 3 feet; hydraulic limestone, manufactured for that purpose here, 5 feet; blue and bituminous shales, 3 feet; coal, 18 inches; fire-clay, 4 feet; and shales and sandstone, about 75 feet.

The stone quarried at Winfield has a uniform light drab or gray color, and is soft and very easily worked. It is quarried by means of plugs and feathers, the holes being bored with a common 1½-inch auger having no point. These holes can be bored by one man at the rate of 6 inches in depth per minute. The stone has a handsome appearance and a good reputation for durability. It is shipped for general architectural purposes to Wellington, Ottawa, Leavenworth, Topeka, Atchison, and Wichita, Kansas; and to Kansas City, Missouri. A hotel, two school-houses, several churches, and other buildings have been constructed of it in Winfield, where over 10 miles of sidewalk have also been paved with flags from the quarry of Messrs. Hodges, Moore & Co. Some of the flags laid down are 10 feet long and 8 feet wide, and much larger sizes can be obtained. The rock occurs in layers from 4 inches to 2 feet in thickness, and the fine even stratification allows the heavier beds to be split into thin flags. There are usually from 4 to 6 feet of good building stone capped by from 3 to 5 feet of rough limestone.

COLORADO, CALIFORNIA, MONTANA, UTAH, ETC.

By William Foster.

In collecting data for the following report, notes were obtained from ledges in regions where the quarry industry is but slight; in some cases observations were made on ledges not yet quarried for building purposes.

The whole line of the foot-hills in the eastern slope of the Rocky mountains, in Colorado, is of outcrops of sandstones which vary considerably in color and texture. They are quarried in many places both for local use and to ship to Denver, which is the chief market for them all.

At Fort Collins a very compact sandstone is taken out for "footings" and foundations of all kinds. It is especially applicable to this purpose on account of its being capable of withstanding great pressure. It is also split into flags for sidewalk paving, but its color makes it objectionable for superstructures, being striped with different shades of reddish-brown. There is another sandstone near the same locality which can be quarried in blocks of any size required and in any quantity; it has a uniform light color and fine grain, and cuts almost as easily as chalk, but grows much harder on exposure.

At Morrison, in Jefferson county, are quite extensive quarries of both red and almost white sandstone of the Jurassic period. The white is only fit for foundations, but the red is a favorite stone for trimmings and also for whole buildings. It absorbs a large amount of water if left lying on wet ground, and then falls to pieces if exposed to frost, but it lasts well in masonry.

At Manitou, El Paso county, an almost white sandstone of the Cretaceous period is quarried, which is now being used in Denver in the construction of Tabor's new opera house; also in the new Union depot, and in many other buildings for trimmings.

At Cañon City, where the Arkansas river cuts through the Cretaceous beds, are two quarries just opened: the Branford on one side and the Berlin on the other. The stone is light greenish in color and cuts very easily, and is being taken out at the Branford quarry for the walls of the new court-house for Arapahoe county at Denver.

At Coal Creek, near Cañon City, is another good sound stone. Still farther south, at Trinidad, Las Animas county, stone is quarried and shipped to Denver. Some "Trinidad stone" was put into the James office building in Denver. A little red granite split from bowlders has been used from a locality owned by the government, the

Platte cañon, between Jefferson and Douglas counties. It will not polish, on account of an excess of mica and hornblende. There are plenty of fine granites all through the mountains, but on account of the expense of working and transportation to market they are not used.

In the immediate vicinity of the town of Castle Rock there is a large amount of lava (rhyolite) quarried, and, as with other stones, Denver is the chief market. The Denver and Rio Grande Railroad Company has used a good deal of it for stations, etc., along the line of its road.

The rock splits in all directions easily with a hammer, has great strength in proportion to its weight, and makes a very handsome building with a stone face or rubble work. It will not take a polish or even answer for nice cut work, as it is porous and full of soft places called "mud-holes" by the workmen.

The only building stone which is quarried in Wyoming is at Sherman, the highest point on the Union Pacific railroad. At this point, the summit of the Black Hills, the road cuts through a very heavy body of red granite similar to the Scotch, but with much larger crystals. The monument to Mr. Ames is being quarried and cut at Sherman. Mark Hopkins, of San Francisco, had some taken out for his residence in that city, for steps, vases, etc.; his tomb at Sacramento is also built of it. The stone is very hard to work, and the sharpest tools are required, or the crystals of feldspar will fly out instead of cutting.

There is plenty of good granite in both Montana and Idaho, but there is no demand for an article which would cost so much there. A little stone has been used in the roughest kind of buildings, such as storehouses, breweries, and for foundations of some buildings, all taken from bowlders. Utah has a great variety of fine stones fit for buildings—marbles, limestones, sandstones, and granites—but as yet no regularly worked quarries. Most of the stone work is done by the Mormon church for its own purposes, and the bodies of rock are mostly public property and free to all.

The granite in Little Cottonwood cañon, used for the new temple in Salt Lake City, is taken from large bowlders which have rolled down from each side of the cañon, and are split up and loaded upon the cars. When the supply gets short, more are rolled down to a convenient place for working. The stone is a very handsome gray, and does not rust on exposure, but there are large, almost black, knots called "nigger-heads", through the bowlders, and care has not been taken to have these come on the inside of the walls of the temple, thus marring what would otherwise be a very handsome building. The supply is unlimited, for when all the bowlders are used the solid ledge may be taken; the formation extends about 3 miles up the cañon on each side. At Red Butte, near Salt Lake City, in the foot-hills, is a red Triassic sandstone, which may be had in several different shades. It has been used for the walls of several buildings, the piers of the old Mormon tabernacle, and for the foundations of many buildings. It is easily obtained, as it lies on the crest and sides of quite steep mountains and can be quarried and rolled down into the cañon below. The supply is so great that there will be no need of deep working for many years. The United States government has used about 7,000 cubic yards of this stone in the construction of the officers' quarters, barracks, storehouses, etc., at camp Douglas. The buildings made of this rock are all of rubble work. A few sample grave-stones have been cut from it, and blocks of the same are used for bases to monuments made of other stone. As all help themselves as they wish, I was unable to get any idea of the amount used each year or the expense of quarrying per ton or per yard.

In Echo cañon, near Croydon, there is a quarry of red sandstone similar to the Red Butte, and probably of the same age, owned by the Union Pacific Railroad Company, and is worked by it for stone to put in bridge piers all along the road. It is considered very good for this purpose, as it does not shake to pieces with the jar of the trains. The company has allowed other parties to take stone for use in the vicinity and at Ogden, but the amount used in that way is small.

From 80 to 150 miles south of Great Salt lake, marble specimens have been found, and also the rock in place, though not of a very good quality, owing to the beds being so twisted and shattered that it is impossible to obtain clear pieces of any size. Payson and San Francisco are the localities where most of the specimens have been obtained.

At Manti, in the Sanpete valley, the Mormons have built a temple of oolitic limestone quarried on the ground. It has a very warm, rich, light brown color, cuts very easily, and yet holds its surface well.

At Ogden the Episcopal church is built of a fossiliferous limestone. I was unable to get samples, as there is no regular work done.

The state of Nevada has quarried some stone in the state-prison grounds at Cañon City by convict labor. The stone is of very coarse sand, and contains fossils of both mollusks and vertebrate animals; also the tracks of some animal with three toes, like a bird, very plain in the surface of the stone which forms the floor of the prison-yard. The tracks are 11 inches long from heel to toe, and are 22 inches apart. The United States mint at Carson, the city hall and county buildings, are all built of this stone, and some was taken to Reno to form a portion of the walls of the state prison. The Carson sandstone is not fit for steps, floors, or any place where there is much wear, as it is coarse-grained and soft, and in such positions has to be replaced often. It also absorbs a large quantity of water, making it unfit for foundations or places where it is likely to be exposed to moisture.

At Virginia City a volcanic rock is used for engine beds at the hoisting-works, and in other places where heavy solid foundations are required. The rock will not take a polish, but makes fine rubble work or stone face. It is quite easily quarried, and when freshly taken out cuts well and grows harder on exposure to the weather. There

is no regularly-worked quarry. Granite is also plentiful in the vicinity of Virginia City, but it is not much used owing to cost of working and transportation. A slab is being cut for the Washington monument. The stone is very heavy and of the best quality, but there is no market to encourage any one to open a quarry. The main part of the walls of the old state prison at Reno is of andesite, taken from a large body of this rock which lies about 2 miles north of the city, very easy of access. The rock forms the top of two low hills, which can be connected very easily by a side-track with the narrow-gauge railroad now building from Reno to Oregon. Reno has a few buildings, such as storehouses, built of it.

The building-stone resources of California are immense in both quantity and quality. The granite quarries of Penryn, Pino, and Rocklin are worked extensively and with system. All the granite used in Sacramento and San Francisco, except a little from New England, comes from these quarries.

Around the northern end of the bay of San Francisco, at Napa, Petaluma, Bridgeport, etc., are immense beds of basalt of several different qualities available for the construction of buildings in the future, but now only used for paving stone in San Francisco, Sacramento, and neighboring cities. A few small buildings have been put up in the vicinity of the quarries. Rhyolite is found near Mokelumne Hill in Calaveras county, of several different colors. It is used so far only in the immediate neighborhood; none has been shipped. Lake and Plumas counties each has many varieties of volcanic rocks, but they have not been sufficiently investigated to determine their value as material for construction. On account of want of means of transportation, it will probably be some time before it is used except locally.

The sandstones are also well represented, both in color and texture, all around the bay of San Francisco. At Armory point, just east of Benicia, the United States government has built a large arsenal of light brown sandstone quarried on the spot. This is all that has been used of it, though the color is handsome and the stone is very durable. Angel island, in the bay of San Francisco, now government property, has furnished a bluish sandstone which was used for the Bank of California building; and as far as I can learn, that is all of any account.

Near Alameda, Livermore, Haywards, and a number of other small places, quarrying has been carried on in a very small way in sandstones of various shades of light brown and blue, mostly for the San Francisco market. At San José, near the southern end of the bay, is a quarry of light brown sandstone of several degrees of coarseness, unlimited in extent, and of very even color. The quarry has only lately been opened, and is now used in the trimmings of the new city hall in San Francisco, and for foundation and trimmings of the State Normal School building, San José, and that is all. It is almost pure silica, and stands fire so well that it is used for lining blast-furnaces and for cupolas, forges, etc.; it cuts very easily, when first quarried, into either ornamental, statuary, or faced stone, and grows very hard on exposure to the weather.

California marbles are so bent and fractured by upheavals that it is hard to get pieces of any size without cracks and cavities.

Thousands of dollars have been spent at Colfax in an attempt to open a deposit of drab marble and get it into market, but the parties failed; some of the material was used for mantels, fireplaces, floor-tiles, etc., but the quantity was small and the stone not much liked, so no work has been done for some years.

The so-called "California onyx" is the most beautiful of the marbles, and a small quantity was found at Suisun. This has now all been worked out. Kessler Brothers own another body of it near San Luis Obispo, and are now doing some very handsome work, such as counters for stores, mantels, fireplaces, vases, table-tops, etc. The quarry has not been opened long, and being far from market little has been used, and the quarry is not regularly worked. The owners are going to try and introduce it into the eastern cities.

In Kern county there are marbles of many shades, but all are more or less broken and shattered, making them very hard to work. At Indian Diggings, Eldorado county, a marble has been quarried with almost white ground and blue streaks running through it, used a little for grave-stones, but not much liked, and is not now quarried.

Arizona and New Mexico at the present time use very little stone for building purposes; the climate does not require it, and "adobe" is much cheaper. The Pueblo Indians once used cut stone in the construction of their dwellings, which are now in good preservation in many places.

Chapter VII.—STONE CONSTRUCTION IN CITIES.

AKRON, OHIO.

Akron has ready access to the celebrated quarries at Amherst, Berea, and other localities. The greater part of its stone construction is of the sandstone quarried from local quarries, while Berea sandstone is also largely used; for foundations and underpinnings the local sandstone is exclusively used. The Akron sandstone, when carefully bedded, makes a very durable building stone, but its strength is not very great when the pressure comes unequally upon it. Memorial Chapel building is of sandstone from Marietta, Ohio. Stone has been but little used in paving the streets, and sandstone from Medina, New York, is the material used for this purpose. The sidewalks are largely paved with Berea sandstone.

ALBANY, NEW YORK.

Stone fronts in Albany are mostly of Connecticut brownstone. Ohio sandstone is used in trimmings. Granite from Maine has been used in some of the finer structures, such as the state capital, city hall, United States court and post office buildings, and the state hall. Among the buildings in which Connecticut brownstone has been used are the Albany academy, cathedral of the Immaculate Conception, Saint John's Roman Catholic church, Saint Peter's church, Second Presbyterian church, Protestant Episcopal church, and Emanuel Baptist church. As in all the towns and cities on the Hudson, Albany is largely of brick; stone is used for large public edifices and in dwelling-house fronts to a limited extent. The cheapness of brick enables them to compete successfully with stone, even in foundations and cellar walls. A great variety of stone has been used in the new capitol building: the mass is Maine granite. In the interior decorations Mexican marble, Bellville sandstone, Ohio sandstone, and Lake Champlain marbles have been used.

Saint Joseph's Roman Catholic church is trimmed with Caen stone; this material weathers badly, and does not stand the severe winters. The Episcopal church, State street, is trimmed with Hudson River sandstone from Schenectady. This material comes out with natural faces, and these are weathered to brownish and greenish-yellow shades of color, giving the front a highly-variegated aspect. The weathering or fading on exposure is seen in different shades of color between the stone of the building proper and the tower: the latter, of later construction, is the darker shade. The Second Reformed church, a large edifice of a composite style of architecture, is of limestone of Trenton age. The foundations and underpinnings are built of limestone from Amsterdam, Howe's cave, Kingston, and Glens Falls: also sandstone from Schenectady, Highland, and other places in Ulster county is used for this purpose. The streets are largely paved with stone, and the materials used are bowlder or cobble-stone and granite blocks from New England: the dimensions of these blocks are usually about 14 by 4 by 8 inches. The following is an approximate statement of the number of miles of pavement of the different materials: 38½ miles of cobble-stone pavements, 4 of granite block pavements, and 1¼ of macadamized pavements: total number of miles, 43¾. Number of miles of unpaved streets, 89¼.

The sidewalks are largely paved with stone, and the materials used for this purpose are the Hudson River blue flag-stone, and blue flags from the Helderberg mountain: also some Potsdam sandstone: the curbstones are of the same materials.

ALLEGHENY, PENNSYLVANIA.

What is true of stone construction in Pittsburgh is also true of it in Allegheny, as the two places are separated only by the Allegheny river, and the sources of their building materials are precisely the same. In rare instances Connecticut brownstone is used, and a very little of New England granite, principally for cemetery work, but nearly all the stone construction is of sandstones and limestones of sub-Carboniferous and Carboniferous age quarried west of the Alleghany mountains, in Pennsylvania and Ohio.

ALLENTOWN, PENNSYLVANIA.

The stone used for foundations and other ordinary purposes of construction in Allentown are limestones and hard sandstones from small quarries in the mountains near the city. Sewers are constructed entirely of brick. The building stone used here is limestone and the mountain sandstone, and is of the most durable quality. The city engineer reports that the ground in some portions of the town is unfavorable to heavy buildings on account of being cavernous. The bridge abutments and arches are built of limestone and quartzite from the mountains near the city. The streets are but little paved with stone, and the material used is cobble-stone from the river. Some

of the streets are macadamized with limestone from the vicinity. There is but little stone sidewalk paving, and the material is the North River and Wyoming blue-stones, but the native limestone from the Lehigh valley is used to some extent for this purpose.

ALTOONA, PENNSYLVANIA.

The sides of the mountains near Altoona are thickly strewn with surface rocks of different geological formations which furnish nearly all the building stone for cellars, foundations, terrace walls, and other ordinary building purposes in the town and vicinity. These surface rocks are durable and very hard from long exposure to the weather. On breaking them up numerous cracks are found, owing probably to the effects of the frequent fires that pass over the mountains. The material is so rough and hard as to make it extremely difficult to dress, and it is therefore not found practicable to use it for any other than the ruder purposes of construction, where dressing is not required. Material from a quarry of what is probably sandstone of Pocono (sub-Carboniferous) age, 2 miles from Altoona, is being introduced to a limited extent for cellar work and foundations. It breaks irregularly and with a conchoidal fracture. The supply of the material which is available is not large, owing to the amount of dip (about 45°) into the hill. For finer cut work some sandstone from Gallitzin, on the Pennsylvania railroad, west of Altoona, and in Cambria county, is used. It has a local use for caps, sills, bases, etc., as far east on the Pennsylvania railroad as Huntingdon, a distance of 60 miles. Amherst and other northern Ohio sandstones are employed to a limited extent for trimmings. The stone work in Altoona is confined chiefly to cellar and foundation work and a few terrace walls, the ground on which the city is built being somewhat uneven. There is scarcely any stone work in the shape of caps, sills, and columns, brick being used, as there is no stone in the immediate vicinity which would be very suitable for these purposes. The streets are paved with cobble-stones from the streams in the vicinity, but there is very little stone sidewalk paving. In front of the Logan house there was formerly considerable pavement, constructed of hard blue slate, which has a smooth, even surface, and presents a pleasing appearance when first put down, but is not durable.

ATLANTA, GEORGIA.

The stone chiefly used in this city is from local quarries. Some is brought from Dixon, Alabama, and Bowling Green, Kentucky, for trimmings. The Stone Mountain granite is shipped west to be dressed, polished, and carved, and then returned. The only buildings constructed entirely of stone are the warehouses. The usual style of building is a foundation and superstructure of brick with stone trimmings. The United States post-office and court-house is built of granite from Vermont. The foundation is the Stone Mountain granite. The new county court-house is to be trimmed with Bowling Green limestone. Several stores are trimmed with Dixon, Alabama, stone. The brick is of very superior quality; stucco is used to some extent; the use of stone is increasing. The city has 133 miles of streets; of these 10 miles are macadamized, and only 7 miles have brick and stone sidewalks; 11 miles of the streets are sewered, and of the sewers about one-third are constructed of stone. The city prisoners work the quarry, and they are employed a portion of the time in macadamizing the streets and roadways.

The city of Atlanta has an abundant supply of rock and good granite accessible. The soil is red clay and furnishes secure foundations. The most durable stone is gneiss, locally called "blue granite". The Stone Mountain granite wears away under attrition, and has not been long enough in use to determine its wearing qualities. The best granite at present known in the state is in Oglethorpe county, but it has not been used much as yet; it resembles very much the Quincy granite of Massachusetts. The growth of Atlanta has been very rapid of late years, and the macadamizing of the streets has proceeded at an average rate of only one mile a year. Granite, chiefly from Lynch's city quarry, is used by the railroads for bridge piers and retaining-walls; the railroad cut in the city is braced in this way.

BALTIMORE, MARYLAND.

The rocks exposed in the immediate vicinity of Baltimore are gneiss of Archæan age, and it was this material that was first drawn upon for the ordinary purposes of stone construction, it being the most convenient. Baltimore has, since its foundation, had ready access to all the important quarries on the eastern sea-coast, and it has drawn largely from this source. There is much of the Connecticut and New Jersey sandstone used; and of late years granite from the quarries on the coast of Maine has been largely employed. In the early times of the city, stone brought as ballast in the numerous ships arriving was used for ordinary purposes. Another important source of supply in later years and at the present time is the marble quarries at Cockeysville, a short distance north of the city. Granite from various points in the state of Maryland has been largely used, especially that quarried at Ellicott City, on the Patapsco river; at Woodstock, in Howard county, and at Jones' falls. Since the city has had railway communication with all points in the interior, serpentine from Chester county, Pennsylvania, and Ohio sandstone have been largely used.

The following are some of the most important stone structures in the city: The Eutaw Place Baptist church, which has a tower 187 feet in height; the Brown Memorial Presbyterian church, corner of Park and Townsend streets;

the Franklin Street Presbyterian church; the city hall, and the Peabody Institute. These are all built of marble chiefly from the Texas and Cockeysville quarries, north of Baltimore. The Peabody Institute exhibits the Maryland marble to good advantage, as care was taken in selecting the material. In several buildings a very few defective stones injure the effect of whole structures. The First Presbyterian church, corner of Madison and Park streets, is built of New Brunswick, New Jersey, sandstone. The city prison is built of gneiss from Jones' falls, with marble trimmings. The Catholic cathedral is built of gneiss from Ellicott City; the foundation-stone of the building was laid on July 6, 1806. The older monuments were erected before marble had been quarried to any great depth, hence the best material was not obtained. The corner-stone of the Washington monument was laid July 4, 1815, and that of the Battle monument September 12, 1815; the lettering upon the latter remains quite distinct, showing that this material, even when not selected with any care, stands the test of time quite well. The Rialto building, Second street; the Kilby building, Baltimore street; the Franklin Bank, Citizens' Bank, Union Bank, and the Farmers' and Planters' Bank buildings are constructed in part of marble from Cockeysville. The foundations and underpinnings are built of gneiss quarried in the vicinity and at Jones' falls, Ellicott City, and Port Deposit; all of these places are readily accessible by water. Granites from Woodstock, Richmond, Virginia, and from the coast of Maine are employed to some extent for the same purposes. In the construction of the Young Men's Christian Association building, the Normal School building, and the Traders' National Bank building, Berea, Ohio, sandstone was used. About three fourths of the streets are paved with stone, the material chiefly used for this purpose being cobble stones and gneiss from Jones' falls and Port Deposit, and granites from Woodstock, and from Virginia and Maine; although brick is the material chiefly used for sidewalk paving, yet much of the North River blue-stone shipped from Rondout, New York, is used for this purpose. Granite from Woodstock, Maryland, and from Richmond, Virginia, and gneiss from Port Deposit, Maryland, are also used for this purpose; the curbstones are of gneiss from Ellicott City and Port Deposit and the granite from Woodstock. The bridge abutments, sea-walls, and the walls of fort McHenry are constructed chiefly of gneiss from Jones' falls and Port Deposit.

BANGOR, MAINE.

The material used for the better class of stone construction in Bangor is granite exclusively, brought chiefly from Frankfort, Maine, and the islands of the Penobscot bay. Underpinnings are of granite. The post-office and custom-house buildings are of granite, chiefly from Musquito mountain, Frankfort. The light granite is largely used in the city for sills, steps, and trimmings generally. The streets are but little paved with stone, and the material is cobble from Mount Desert island and other islands in Penobscot bay, and some also from the vicinity of the city. The sidewalks are paved with brick and concrete, no stone being used for this purpose. Curbstones and crossings are of granite.

BINGHAMTON, NEW YORK.

There is little stone construction in Binghamton, and the material used almost exclusively is limestone from a quarry in the vicinity of Syracuse. A little stone for railroad work comes from Nineveh. The streets are not paved; sidewalks are largely paved with sandstone from the Wyoming blue-stone region in Pennsylvania, and curbstones are of the same material. Some stone from Oxford, Chenango county, is also used for sidewalk pavements.

BOSTON, MASSACHUSETTS.

By JOHN ELIOT WOLFF, *Assistant in Geology in Harvard University.*

HISTORICAL ACCOUNT.

When the first settlers came to Boston, over two hundred and fifty years ago, they probably found the land on which the city now stands covered with an abundant supply of our New England bowlders, which were at once useful in the construction of buildings, just as they are now used in the country; but it seems probable that no ledge of rock was found in the old town, outcropping through the thick clay covering, although there has been some difference of opinion on this point.(*a*) That they began at once to use stone for houses is shown in the following record: "Oct. 30th, 1630. A stone house which the governor was erecting at Mystick was washed down to the ground in a violent storm, the walls being laid in clay instead of lime."(*b*) "A few houses were built of stone and some of brick, but these were exceptions to the general rule, until Boston had become over twenty years of age."(*c*) About 1650 Johnson says of the city, "* * * the buildings, beautiful and large, some fairly set forth with brick, tile, stone, and slate."

There existed until 1864 a stone house built about this time (1650), which was early known as the "Stone house of Deacon John Phillips". * * * "It was built chiefly of stone, the common rocks found in the native soil of

a Cf. *Mem. Hist. Boston*, Vol. I, p. 264, note. S. Gedney: *Mem. American Acad.*, Vol. III, 1809, and others.

b Snow's *History of Boston*, p. 40.

c Shurtleff's *History of Boston*, p. 589.

the peninsula having been broken into various shapes and sizes, and laid into place in the rough form left by the maul of the workman, the massive chimneys, with their spacious fireplaces, constructed of large coarse bricks and stones of uncommon size, were, as far as practicable, on the outside of the building, and portions of the house were covered with thick slate stones at the top of each of the stories." (*a*) Another writer, however, says that "the foundation walls were four feet thick or more; the walls above ground were two feet in thickness, and built entirely of small quarried stones, unlike anything to be seen in this neighborhood, and were probably brought as ballast from some part of Europe." (*b*)

When Josselyn visited Boston, in 1663, he found many large streets largely paved with pebble, and, near the common, some fine buildings constructed of stone; and Ward said in 1699: "The Buildings, like their Women, being Neat and Handsome, and their Streets, like the Hearts of the male Inhabitants, are Paved with Pebble." In fact for some two hundred years the streets were paved almost exclusively with cobble-stones obtained from neighboring beaches, and perhaps from gravel-pits, until granite blocks began to be used. Drake says that the paving of the public streets began very early, and was made of importance after 1700; the sidewalks were also early paved with cobble-stones and flags. (*c*)

The red Connecticut sandstone was shipped to Boston very early. In 1665 ordinances were passed in Portland, Connecticut, relating to the use of this stone by outsiders, which seems to have been used in Boston within the first hundred years; thus the Old Province house, erected in 1679, is described as having a flight of twenty massive red freestone steps; the freestone used in 1737 in the Hancock house came from Middletown, Connecticut. In consequence of extensive fires, laws were passed in 1692 and 1699 concerning the construction of stone houses—that of 1692 decreeing, "that henceforth no dwelling-house in Boston shall be erected and set up, except of stone and brick, and covered with slate or tile". It could not, however, be enforced. The old triangular warehouse which stood near North Market street, and was built about this time, had three turrets covered with slate, and slate was used for roofing very early; this was probably in part imported from Wales, in part obtained in Massachusetts. Professor Shaler says on this point:

> From the slates and conglomerates of the Cambridge and Roxbury series the first quarried stones of this colony were taken. The flagging slates of Quincy, at the base of Squantum Neck, were perhaps the first that were extensively quarried. A large number of the old tombstones of this region were from these quarries. The next in use were the similar but less perfect slates of Cambridge and Somerville; and last to come into use were the conglomerates and granites that require much greater skill and labor on the part of the quarrymen to work them. At first the field-bowlders supplied the stone for underpinning houses and other wall work; so that the demand for grave-stones was, during all the first and for most of the second century of the existence of the town, the only demand that led to the exploration of the quarry rocks of this neighborhood. Indeed, we may say that the exploration of the excellent building and ornamental stones so abundant here has been barely begun within the last two decades. (*d*)

In the Massachusetts records there is a letter dated 1721 describing a visit to Haugman's island in "Braintry" bay, and to Hough's Neck near Squantum, and a return with a cargo of 20 tons of split slate, showing how extensively it was used even then. The use of stone for walls, steps, and underpinning was constantly increasing, and we find that the inhabitants of Quincy were alarmed at the rapid manner in which the bowlders disappeared from their fields, for in 1715 and 1729–'30 the town passed laws regulating their use. (*e*)

In 1737 the old Hancock house (taken down twenty years ago) was built of Braintree bowlders, squared and hammered, with red freestone trimmings from Middletown, Connecticut, and it was slated (probably at some later date) with slate from Lancaster, Massachusetts.

From 1749–'54 was built King's chapel, now standing on Tremont street—at that time the greatest stone construction ever attempted in Boston, if not in the whole country. It was built of coarse bowlders dug out of the ground at both the north and south commons, Quincy (Braintree), and then split and hammered. The bowlders were split up for this building, it is said, by heating the stone (by building a fire upon it), and then splitting it by letting heavy iron balls fall upon it; in fact squared and hammered granite had only been used a short time before this in Boston, as the art of working it to a smooth surface is said to have been introduced about this time by German immigrants who settled at Quincy. Of course granite obtained in this way was very expensive and the process could best be applied only to bowlders having a free side.

> When this work was finished it was the wonder of the country round. People coming from a distance made it an object to see and admire this great structure. The wonder was that stone enough could be found in the vicinity of Boston fit for the hammer to construct such an entire building. But it seemed to be universally conceded that enough more like it could not be found to build such another. (*f*)

In 1774 the old powder-house was built of Braintree granite, with walls 7 feet thick; and in 1793 the stone light-house was built on Light-house (or Beacon) island.

About this time marble began to come into use for building, corresponding to the opening of the Berkshire, Massachusetts, marble quarries (1790), for the state-house, built 1795–'98, is described in old books as having keystones, imposts, etc., of white marble; part of this came from Boynton's quarry in West Stockbridge, Berkshire county. (*g*) Thus the "new almshouse", erected in 1800, had marble trimmings; and the Exchange coffee-house,

a Shurtleff, *loc. cit.*, p. 666.
b Savage, *Felice Record*.
c *Old Landmarks*, p. 21.
d *Mem. Hist. Boston*, Vol. I, p. 5.
e Paltee's *Hist. of Quincy*, p. 500.
f Chief Justice Shaw, *Proc. Am. Acad.*, 1859, IV, p. 353, etc.
g D. D. Field's *History of Berkshire County*, p. 275.

erected in 1805–'08, had six large marble columns or pilasters upon a rustic basement, supporting an architrave and a cornice of the same stone. The base of the building was of hammered granite and the basement of white marble. The old custom-house, built in 1810, had also marble trimmings.

About the beginning of this century came a turning point in stone construction in Boston and the country generally, coincident with the changes in the method of splitting granite. According to Chief Justice Shaw (*loc. cit.*) this was determined by the introduction of the method of splitting granite by drilling holes and then driving in small wedges. The construction of the first part of the Massachusetts state prison in Charlestown, finished in 1805, seems to have been the cause for the introduction of this method of splitting granite by drilling holes and driving in small wedges, now universally used; so that this building, together with Bunker Hill monument and King's chapel, must be regarded as of great historical importance in the development of granite construction in the United States.

Shortly after the beginning of this century, then, granite began to be used extensively in Boston, and of two varieties: white granite (the so-called Chelmsford) from Tyngsborough and Westford, near Lowell, Massachusetts, and perhaps some from Pelham, New Hampshire, and other places—quarried generally, if not entirely, from loose bowlders for many years; and the dark Quincy granite, mostly from bowlders, but a little from ledges. Thus in 1810 the court-house (old city hall) was built of white Chelmsford stone on the site of the present building, in the walls of which some of the old stone has been retained; in 1814 the New South church was built of the best Chelmsford granite. About the same time, what is now the Congregational house, on Beacon street, was built; the old Parkman house on Bowdoin square, University hall in Cambridge, and others, all of Chelmsford granite; and from 1818 to 1821 the main part of the Massachusetts general hospital, with several large granite columns, was hammered at the state prison—also of Chelmsford stone—probably from bowlders.

The completion of the Middlesex canal to Chelmsford (30 miles) in 1803, itself a great work, with sixteen locks of hewn granite, opened the way for the easy transportation of granite from the vicinity of Chelmsford, so that it could be delivered in the very streets of the city, and great quantities were landed at the state's prison in Charlestown and cut by the convicts. All, or nearly all, of this stone came from surface bowlders, as is stated, as late as 1820, (*a*) and were split as at Quincy; in 1818 a church was built of this stone in Savannah, Georgia, and $25,000 worth was sold.

In 1818–'19 there was built of this material the first stone block in Boston, still standing on Brattle street, and forming originally a block of fourteen buildings, part of which now form the old part of the Quincy house. Stores erected on Cornhill in 1817 were the first erected in the city on granite pillars, and in 1820 these were first substituted in brick buildings already standing. (*b*) In 1829 Saint Paul's church on Tremont street was built of Quincy granite with large columns and portico of yellow sandstone from Acquia creek, Virginia. Some yellow sandstone from England was used in buildings on Cornhill in 1817.

The mill-dam connecting Boston with Brookline and Roxbury, and built from 1818 to 1821, was considered one of the greatest constructions of the kind in the world. The sides of the dam are built of solid stone for 8,000 feet in length, from 8 to 3 feet thick, and 12 to 17 feet high, while the width between the walls varies from 50 to 100 feet. The stone used was Roxbury pudding-stone and stone from Weymouth.

In 1824 the United States branch bank was built on State street of Chelmsford granite, and has been called the first building constructed of large stone (the state's prison, however, should be noted); a part of this building still remains in its successor, the Merchants' Bank building, and the two columns in the present front were taken from the two in the original building, but reduced in size. These two columns were originally 24 feet high, including the cap, and 4 feet in diameter at the base, and were cut from a large bowlder of granite in Westford, Massachusetts.

The next year the construction of Bunker Hill monument began (1825–1842), the greatest monument of its kind in the world, and marking a most important step in stone construction in this country. The architect was the well-known Mr. Solomon Willard, and the master mason Mr. Gridley Bryant. To these two men is largely due the development of stone construction in Boston.

After his appointment as architect, Mr. Willard spent considerable time in looking up a quarry, and finally decided on the Bunker Hill quarry in Quincy, from which the stone was accordingly taken, and it was for the purpose of transporting to tide-water the stone for the monument that Mr. Bryant built the first railroad in America.

From the *Memoir of Solomon Willard*, by William W. Wheildon, we quote as follows:

> The opening of the Bunker Hill quarry led to the discovery and opening of other quarries, caused the building of the first railroad in the country, and gave an impulse to business which has adorned our cities with a class of splendid and substantial buildings, both public and private, which for durability and beauty are wholly unsurpassed.
>
> Mr. Willard felt persuaded that an improvement in the material for building purposes so decided as that which he, in fact, had introduced would gradually effect a change in the style of building and in the general architecture of the times. Granite, as a building material, excepting in a few instances, and these mostly under Mr. Willard's superintendence, had been used in small pieces or blocks of

a W. Allen's *Hist. of Chelmsford, Mass.*

b Snow's *Hist.*, p. 328, note.

moderate size for cellar walls, underpinning, posts, lintels, etc., and his first measure was to introduce the material in large blocks, such as were in themselves massive and durable, which, as he saw at once, would absolutely necessitate changes in the style of architecture and in the character of public buildings, stores, and other substantial structures.

In 1825–'26 the Quincy market was built of Chelmsford (and Hallowell) granite, with large columns of the same at each end of the building. Soon large buildings were put up of Quincy granite, and the construction of stone buildings went rapidly forward after 1830 to the present time, so that only a general mention is possible:

The Tremont house, 1828–'29, granite; dry dock at navy-yard, 1827–'34; old Trinity church, 1828; Masonic temple (United States court-house), 1830–'31; Suffolk County court-house, 1833–'36; and the United States custom-house, 1837–1848, may be mentioned as opening the great development in the construction of Quincy granite buildings, and as showing how the Quincy granite supplanted the Chelmsford. In 1848 we find already thirty or forty blocks of granite mentioned in the city. The eight stone columns put in the county court-house (1835) were of importance, each one requiring 65 yoke of oxen and 12 horses to transport it; and also those put up in the Merchants' exchange, in 1842—the largest in the city—may be mentioned. About this time there was a considerable use of the Somerville diabase for basements of brick buildings and of red sandstone for trimmings. About 1845 the red sandstone came in for fronts, and several churches, the Boston Athenæum, etc., were soon erected. The *Times* building on State street is said to have been the first building with a red-freestone front. Rockport granite began to be used from the quarries about 1830, and was at first put into cellars for brick buildings, and then for posts in North and South Market streets. The first building of hammered Rockport stone was that of Terice How & Co., about 1846, and the Beacon Hill reservoir, a little later, of Rockport stone, was a very extensive undertaking. The Parker house, erected in 1854, was the first marble building in the city. Concord granite was first used in columns in the Boston and Albany depot; the Merchants' Bank building was perhaps the first front (1856) of Concord granite. The Washington building at the head of Franklin street is said to have been the first building of Nova Scotia freestone (1858). Within the last twenty-five years various other building stones have been introduced: the Roxbury pudding-stone for churches, the different marbles and sandstones, and lastly the red granites. The building up of the Back bay has been very extensively done with sandstone fronts. The great fire in 1872 wiped out hundreds of stone buildings and blocks which had been erected during forty years in the business portion of the city. The buildings were very largely Quincy granite, Rockport, Concord, Hallowell, etc., and in their places have sprung up buildings of lighter-colored stone, Concord and Rockport granites, and a great proportion of buildings of the yellow sandstones of Ohio and the provinces, together with many marble buildings.

STATISTICS.

According to the assessor's list for 1880 there are about 51,000 dwelling-houses, stores, and other buildings in the city of Boston. The following figures can be compared with those above only approximately, on account of the probable differences in making the count; for in the figures for stone buildings, what appeared to be separate constructions were counted as units, and several dwelling-houses may make up one stone building. There are in the city limits of Boston, by actual count: (*a*)

	Buildings.	All stone.	Fronts, one to three sides.
Total	752	93	659
Quincy syenitic granite	162	28	134
Concord granite—two or three from Fitzwilliam, New Hampshire	79	2	77
Cape Ann granite	40	9	31
Chelmsford granite	16	5	11
Hallowell, Maine, granite	5	0	5
Rollstone Hill granite, Fitchburg	1	1	0
Jonesboro', Maine, red granite	5	0	5
Vinal Haven, Maine, granite	1	0	1
Somerville, Mass., granite	1	0	1
Frankfort, Maine, granite Co.	1	0	1
Unknown granite	1	0	1
Total granite	312	45	267
Marble (Vermont, etc.)	58	0	58
Tuckahoe, New York, dolomite (marble)	10	0	10
Total marble	68	0	68
Connecticut valley, New Jersey, and the provinces, red sandstone	211	3	208
Connecticut valley, New Jersey, and the Ohio, part red, part yellow sandstone	116	2	114
Total sandstone	327	5	322
Roxbury pudding-stone	35–40	3–4	0
Cambridge slate	3	2	1
Dedham porphyr	1	1	0
Unknown (quartzite?)	1	0	1

a This is a close approximation, but cannot of course pretend to be accurate to a single building.

Therefore between 1½ and 2 per cent. of the buildings of the city are of stone. Some of the more important constructions of the different kinds of stone are:

QUINCY GRANITE.—United States custom house (1837–'48) is constructed in the form of a Greek cross. It is surrounded by 32 massive stone columns, each of which is 5 feet 2 inches in diameter, 32 feet high, and weighs 42 tons. The roof and dome are covered with granite tiles worked at Quincy; there is said to be about the same amount of stone in this building as in Bunker Hill monument—6,700 tons. The county court-house (1833–'36); there were originally eight stone columns 25 feet 6 inches high and 4 feet 6 inches in diameter, weighing 50 tons each. Suffolk County jail (1851); there is also some stone in the building from the Rockport Granite Company. Charlestown state prison (1805, 1828, and 1850); the old part was probably in large part from bowlders; some of the blocks were 9 feet long and 20 inches thick (1805). United States court-house (1830–'31); Masonic temple; Tremont house (1828–'29); King's chapel, 1754—bowlders; Saint Paul's church (1820); the yellow sandstone columns, etc., from Acquia creek, Virginia; Howard Athenæum (1846); Merchants' exchange (1842), Wigwam quarry. The pilasters in front of this building are the largest in the city; the large ones are 11 feet 8 inches long, 6 feet wide, and weigh 50 tons; Boston Museum (1846); Merchants' National bank (in part); Suffolk National bank; State Street block; State Street wharf building; United States warehouse, Union wharf; Lewis wharf building; Commercial wharf building; Commercial block; Long wharf building; the buildings of Hovey & Co. and of Hogg, Brown & Taylor; Mount Vernon church; Unitarian church, Jamaica Plain; Bowdoin Square Baptist church; Catholic church, Broadway, South Boston; many of the buildings in the navy-yard, Charlestown; United States dry dock; basements of Equitable Life Insurance and New England Mutual, and many other large buildings; lastly, Bunker Hill monument, from the Bunker Hill quarry. The monument has two parts, an inside and an outside; the outside part is in form a square pyramid or obelisk, 30 feet square at the base, and tapering gradually. A pyramid of stone 13 feet high tops this, so that the total height is 221 feet 5 inches. Inside the pyramid there is a hollow cone of stone with a circular section (diameter at base 10 feet), and between the outside wall of the cone and the inside wall of the pyramid are placed the stone steps. There are, therefore, four wrought stone surfaces in the monument extending from top to bottom. There are said to be 6,700 tons of granite; a little of the stone inside is said to be Chelmsford granite. Height of monument to the apex, 221 feet 5 inches; height of obelisk to base of pyramid, 208 feet 5 inches; sides of the square, first course, 30 feet to 15 inches; height of the cone, 196 feet 9 inches; diameter, 10 feet to 6 feet 2 inches; pyramid 13 feet high; sides of base 15 feet.

CAPE ANN GRANITE.—The United States post-office (1869–'82) is the finest granite building in the city. The stone was all furnished from Gloucester, the basement of darker stone from the Blood quarry, and the superstructure from the "Old Pit" quarry. The superstructure of that part of the building first erected was taken essentially from one immense sheet in the quarry; the stone is syenite. The pavement on the floor is from Swanton, Vermont. Lake Champlain, Sicilian, and Sienna marbles have been used in the interior; the roof is slate, from western Vermont. The Boston water-works is an immense granite structure on the side of Beacon hill; the basin is of Westford granite. Lawrence building, Fremont street; the building of Bigelow Kennard & Co., Washington street; Wesleyan hall; Commonwealth building, Water street; Saint Vincent de Paul church, South Boston; church of Our Most Holy Redeemer, East Boston; the rope-walk at the navy-yard, 1,360 feet long; South Boston Savings bank, and many stores on the business streets.

CONCORD GRANITE.—*Herald* building; *Transcript* building; Wentworth building; Emigrant Savings bank; city hall; Massachusetts Historical Society building; Suffolk Savings bank; Horticultural hall; Masonic temple; the *Advertiser* building; Merchants' National bank; National City bank; Lawrence building, Devonshire street; Rialto building; New England Mutual Life Insurance Company's building; building corner Summer and Bedford streets; building on Winthrop square; Brooks estate, Pearl street; Union Institute for Savings, Bedford street; Bowditch block, South street; Odd Fellows' Memorial hall (in part), 27–50 High street; and Cruff's block on Pearl street, from Fitzwilliam, New Hampshire.

CHELMSFORD GRANITE (WESTFORD, etc.)—Massachusetts general hospital, the original part (1818–'21) from bowlders, probably hammered at the state's prison; addition of 1846 from Westford. Quincy market (1825–'26) with some Hallowell granite; two blocks of stores, north and south of the market; church of the Immaculate Conception; Congregational house; Somerset club, Beacon street; Quincy house (old part); Parkman house; part of the Merchants' National bank and new city hall; basin of Boston water-works.

HALLOWELL, MAINE, GRANITE.—Equitable Insurance Company's building; Odd Fellows' Memorial hall (part Concord); some in Quincy market; Mutual Life of Maine, Tremont street; National Bank of the Republic; large block in Winthrop square (in part).

ROLLSTONE HILL, FITCHBURG, MASSACHUSETTS.—Fitchburg depot (1847).

JONESBORO', MAINE (Bodwell Granite Company), RED GRANITE.—Wellington Brothers' building and Nevin Brothers' building, on Chauncey street; the Morse block, South street; and the Preston building, Summer street.

SAINT GEORGE, NEW BRUNSWICK, RED GRANITE.—Bedford building, Summer and Bedford streets.

VINAL HAVEN, MAINE, REDDISH GRANITE (Bodwell Granite Company).—Building corner Kingston, Bedford, and Columbia streets.

MEDFORD OR SOMERVILLE BLACK GRANITE (diabase).—Front, corner Harrison avenue and Way street.

PORPHYRITIC GRANITE FROM FRANKFORT, MAINE.—Gernish block (1849).

MARBLE.—Goldthwaite & Co.'s store, Washington street: from Sutherland Falls, Vermont; Commonwealth hotel, Continental block, Washington street, Boston Penny Savings bank: from Pittsford, Vermont; Parker house, on School street (1854): from Rutland, Vermont; Blackstone National bank, Commonwealth Insurance Company: from Pittsford, Vermont; Bowdoin building, Bedford building, Summer and Bedford streets: from Sutherland Falls, Vermont: Rogers' building, hotel Comfort: from Rutland, Vermont; building corner Franklin and Pearl streets: from Sutherland Falls, Vermont; Saint Cloud hotel, hotel Dartmouth: from Rutland, Vermont; old part of hotel Vendome, Italian marble; Richardson building, Devonshire street: from Lee, Massachusetts; block of stores on Pearl street (Nos. 113–151): from Alford, Massachusetts.

TUCKAHOE, NEW YORK, MARBLE (DOLOMITE).—Sears' building; McCullar & Parker's building; Mason & Hamlin Organ Company's building; Chandler's building, Devonshire street; large building corner Devonshire and Franklin streets; New York Mutual Life Insurance Company's building, one of the finest stone buildings in the country: from the quarry at Tuckahoe, New York; Montgomery building, Summer and Chauncey, hotel Vendôme (new part): from Tuckahoe, New York.

RED SANDSTONE FROM CONNECTICUT VALLEY AND NEW JERSEY.—Church of the Messiah, Florence street (1848): from New Jersey: 681 Washington street: from Longmeadow, Massachusetts; Evans house: from Portland, Connecticut; hotel Pelham: from Portland, Connecticut, and New Jersey; Brewer building: from Connecticut; Boston Athenæum: from Little Falls, New Jersey; Second Unitarian church, Boylston street: from Newark, New Jersey; Arlington Street church: from Belleville and Little Falls, New Jersey; five houses on Mount Vernon street: from Portland, Connecticut; and great numbers of fronts in the Back bay and elsewhere.

RED SANDSTONE FROM THE PROVINCES.—Wilde buildings, New Washington street: from Mary's Point, New Brunswick; buildings of Palmer, Batchelder & Co., Jordan, Marsh & Co., Boylston bank, Young Men's Christian Union, Boylston street; Channing building, Franklin street; Howard buildings, Arch street; Richardson's building, Federal street: from Bay View, New Brunswick; Bristol building, Boylston street: from Wood's Point, New Brunswick: bank building in Charlestown: from Bay View; Liberty building: from Wood's Point; buildings of Currier & Chamberlain, Washington street, and Minot, Hooper & Co., Ringston street: from Mary's Point: many fronts in Back bay and elsewhere.

YELLOW TO WHITE SANDSTONE FROM BEREA AND AMHERST, OHIO, AND FROM NOVA SCOTIA AND NEW BRUNSWICK, ETC.—Saint Paul's church (1820), columns, etc.: from Acquia creek, Virginia: Wilde buildings: from Caledonia, New Brunswick; Associates' building (Leopold Morse & Co.): from Berea, Ohio; buildings of Palmer, Batchelder & Co.: from Caledonia, and Mary's Point; Shreeve, Crump & Low: from Amherst and Berea, Ohio; R. H. White & Co.: from Amherst, Ohio; Boylston Bank building: from New Brunswick Freestone Company; Dobson's building: from Amherst, Ohio; Call & Tuttle, 459 Washington street: from Caledonia, New Brunswick; hotel Boylston: from Amherst and Berea, Ohio; Young Men's Christian Union: from Amherst, Ohio; Tremont National bank: from Bay View; Simmons' building: from Berea, Ohio; Metropolitan National bank: from Amherst, Ohio; Angelo building: from Ohio; Minot, Hooper & Co.: from Bay View; Harvard College building, Arch street: from Amherst, Ohio; Richardson's building, Federal street: from Bay View; Rice, Kendall & Co., Federal street: from Berea; Alexander building, Washington street, and Sargent's block, Lincoln street: from Mary's Point and Caledonia, New Brunswick; extension Young's hotel: from Caledonia, New Brunswick: Rand, Avery & Co., Mason building (trimmings): New Brunswick freestone.

ROXBURY CONGLOMERATE OR PUDDING-STONE.—First church, Marlborough and Berkeley streets; Brattle Square church; Central Congregational church, Leilseley and Newbury streets: Emanuel church, Newbury street: new Old South church; Second Universalist church; Tremont Street Methodist Episcopal church; cathedral of the Holy Cross; Saint James (Episcopal) church: Mission church, Tremont street; Saint Peter's church, Dorchester; Saint Columbkille church, Brighton; Saint John's church and the Bussey institution, Jamaica Plain, and several others.

SOMERVILLE OR CAMBRIDGE SLATE.—Saint Francis de Sales church, Charlestown.

DEDHAM PORPHYRY OR FELSITE.—Trinity church, from Mr. Bullard's quarry, Dedham.

The city has been very fortunate in having close at hand such an excellent stone as the Roxbury conglomerate for certain purposes. It has been used almost entirely for churches, the stone being so laid up that the exposed surface is that of a natural joint, the rusty-brown color of which is very effective in massive buildings; but of course this use of joint surfaces adds to the expense.

In the trimmings of buildings the red sandstones of Connecticut valley, of New Jersey, and of the provinces have been universally used with brick, and also the yellow sandstones to a considerable extent, while the granites have been used somewhat, especially in the large brick buildings. With the Roxbury conglomerate red and yellow sandstone are used, but the Catholic churches seem to prefer Rockport granite. The new Old South is trimmed with yellow sandstone from Amherst, Ohio, and red sandstone from Longmeadow, Massachusetts. Quincy, Rockport, and Concord granites are the most used for trimmings and supports; also granite from Spruce Head and Hallowell, Maine. The new Boston and Albany depot is trimmed with two shades of the gneiss from Monson, Massachusetts. The

Mechanics' Charitable Association's new building has steps, etc., from Sullivan, Maine. The Boston and Albany Railroad round house, East Boston elevator, etc., are trimmed with granite from Braggville, Massachusetts. In Gilman & Cheney's building, Charlestown, granite from Deer Isle, Maine, has been used. Red granite from Westerly, Rhode Island, has been used in some churches. Coarse porphyritic granite (Frankfort, Maine) has been used in houses on Harrison avenue.

Marble has been used for trimmings in some large buildings, and the Tuckahoe dolomite a little, *e. g.*, in a house opposite the state house. The blue or dove marbles have been used in several buildings of white marble; that in the Sears and Montgomery buildings is from Dover, New York; another dove marble (Rogers and other buildings) comes from Rutland. The gray marble from Isle La Motte, lake Champlain, has been used for trimmings in a few buildings (Summer and Pearl streets). In the Richardson building on Federal street the beautiful green serpentine from Chester, Pennsylvania, has been used with marble, but it has crumbled badly with the exposure; the same stone used in Philadelphia has stood well (University of Pennsylvania buildings). The Hudson River blue-stone has been used for trimmings with Tuckahoe marble in the building corner Devonshire and Franklin streets. The bright red sandstone from Potsdam, New York, has been used a little (columns and trimmings of house Myrtle and Hancock streets, and in Raynor block, in Union street).

For polished granite ornamentation there has been a considerable use in columns on the exterior of buildings (red Scotch, Saint George, New Brunswick, Red Beach, and Jonesboro', Maine); dark red and pink Quincy and gneiss columns (new Old South church). In Wellington Brothers' and Nevin Brothers' buildings are polished columns of Vinal Haven, Maine, granite. In the Wentworth building are columns of the porphyritic Shap granite (English); in the hotel, Boylston avenue, some very beautiful columns of red Quincy; the dark may be seen in the Tremont National bank, Providence depot, and many other buildings. In the *Herald* and Bedford buildings may be seen polished Saint George granite, Scotch and Jonesboro' in many others. At No. 55 High street, in the Mason building, the Bedford building, and elsewhere the underpinning or granite supports are of polished work.

For foundations the granites of Quincy and cape Ann, together with Cambridge slate and Roxbury stone, are used. The Somerville diabase was extensively used forty years ago, and about forty-five years ago the rails of the Lowell railroad from Boston to Medford were laid on a foundation of this stone from Dane ledge, Somerville.

For underpinning, Quincy, Rockport, and Concord granites are generally used; red and yellow sandstones also very extensively in dwellings. In Charlestown the Somerville slate and in Roxbury and Jamaica Plain the conglomerate are largely used, on account of the proximity to the ledges. Hallowell, Spruce Head, Vinal Haven, Deer Isle, and other granites have been used. In the very old houses one sees generally the white Chelmsford granite, looking very rough, as the bush-hammer had not been invented forty years ago. At that time the Somerville diabase was very extensively used for underpinning in Tremont and Hanover streets, Harrison avenue, and in the neighborhood of the Charles Street jail. In many of these old streets the Connecticut sandstone was profusely used, and, being of poor quality then, shows the effects of the frost very plainly. Marble and Hudson River blue-stone have also been used. The handsome granite basement of the Art Museum building is from Mr. Corliss' quarry at Randolph, Massachusetts.

Posts and walls are made generally from the varieties of granite—Quincy, Rockport, and Concord; mainly for posts, Spruce Head diabase, etc.; the granites and sandstones for steps; for walls, Quincy, Rockport, Concord, and Chelmsford sandstone, conglomerate, and slate.

As mentioned before, the streets were early paved with the cobble-stones from the beaches, and these were generally used until about 1840, when Mr. Willard laid the first paving blocks of Quincy granite in front of the Tremont house; they were very large at first—18 inches by 14 feet—but became smaller until about a foot square. For a while (1856) blocks of trap from Bergen hill, New Jersey, were used, until in 1858 Mr. Henry Barker, of Quincy, introduced the small granite pavers which have since been universally used. At present the paving stones come from Rockport, Quincy, and the Maine quarries—all of granite. Granite curbs were used long ago; at present Quincy and Rockport furnish most; some are of Hudson River blue-stone. There are 355 miles of public streets and about 410 miles in all; of these 67 miles are paved.

Sidewalks were flagged or paved in this century. Before the North River flagging came into use in the city, quantities of the Beaton, Connecticut, flagging (a mica-schist, wearing down easily) were laid down. Pemberton square is still largely flagged with these, and many other places in the city, where it still lingers. At present, while brick is generally used, the business streets are flagged with North River stone and granite flags, the granite principally from Rockport and Quincy. Red sandstone flagging is used once or twice. For crossings, North River stone and granite; a great deal of the granite comes from the old-fashioned paving blocks. For the catch-basins of the sewers Rockport granite is largely used. In some of the old city sewers pudding-stone has been used for side walls, and especially for culverts; in some cases the old brick sewers were covered on top with slate. In the improved sewerage construction at Moon island considerable masonry has been used in the pumping station—the granite from cape Ann, Quincy, and Mount Desert.

The reservoir of the Boston water-works on Beacon hill has been described. At the Chestnut Hill reservoir the lining is trap and pudding-stone with a cap of Douglass mica-schist. The East Boston and South Boston reservoirs are lined with Quincy granite. The Parker Hill reservoir has a pudding stone wash-wall with cap of

granite from Graniteville, Massachusetts. The Mystic reservoir has a granite cap. The Sudbury River conduit crosses Charles river over a bridge 475 feet long, of granite from the Cape Ann Granite Company; and the Waban Valley bridge of the same, 536 feet long, is from Spruce Head and Deer Isle, Maine. Three dams are built of Farmington and Cape Ann granite, etc.

The abutments of the Boston bridges are of granite from Quincy, cape Ann, and various other places; the West Chester Park bridge, for instance, is of Milford, Cape Ann, Deer Isle, and Mount Desert granite. For the walls and abutments and other stone-work of railroads, granites, pudding-stone, diabase, slate, etc., are used: the Braggville granite was used quite largely by the Boston and Albany railroad.

For the sea-walls surrounding the city, Rockport and Quincy granites, Somerville diabase, pudding-stone, etc., have been used. In the sea-walls built extensively in the harbor on Gallop island, Point Allerton, Long island, etc., granite has been used—a great deal from Biddeford and Bamebrush, Maine.

Forts Winthrop, Warren, and Independence, in the harbor, are of granite from Quincy, Rockport, and other quarries. Boston Light and Minot's Ledge light-houses are of stone.

ROOFING.—The John Hancock house and old state-house were slated from Lancaster; but the Welsh slates were used in Boston probably two hundred years ago. The Lancaster quarry furnished great amounts of slate to the city after the Revolution, and the slate quarries near Brattleboro', Vermont, furnished slate early in this century. About thirty-five years ago the slates from western Vermont and the Maine slates came into use for roofing, and their use has steadily increased until very little Welsh slate is now used. At or after the time of the war, slate from Buckingham county, Virginia, was used in many buildings of the city. At the present time the roofing slates used come from Piscataquis county, Maine, and from Vermont, Pennsylvania, New York, and Wales. The green, red, and purple slates of western Vermont, and New York state, etc., are extensively used. We may mention the following examples: Trinity church (in part), Clarendon Baptist church, and Saint Mary's cathedral: from Brownville, Maine: new Latin school: from Monson, Maine: cathedral of the Holy Cross, Park Street church, and Bowdoin Square church: Welsh-Penrhyn: navy-yard buildings: Maine and Welsh; Lowell Railroad station and city hall, Charlestown: Pennsylvania slate: post-office, and Eastern Railroad station: Vermont slate; Baptist church in Cambridge: Virginia slate.

The use of slate by marbleizing for mantels, chimney-pieces, tables, etc., began about thirty years ago; and it is used for tiling, slabs, etc., as elsewhere in the country.

Ornamental marbles were in use at least thirty-five years ago in Boston; the "black and gold", Bardillo, and Italian dove were most used then, and the others gradually came in—the German marbles last. The use of the blue marbles of Dover, Pittsford, and Rutland in the exterior trimmings has been mentioned: some of the other veined marbles have been slightly used (Sears building), and the Winooski Vermont marble in columns (Masonic temple), and black marble (Parker house). In the interiors of buildings the ornamental marbles have been frequently used, and in great variety, *e. g.*, the Art Museum, New York Mutual, *Herald*, Marlborough, and many other buildings; and of course considerably for mantel-pieces, soda fountains, etc. The following have perhaps been most used in the city:

Yellow Sienna: Italy; Saint Baume, Jaune Fleuri, and Lumachelle, France.

Black: from Glens Falls, New York, and elsewhere.

Red: Lisbon, Portugal; Victoria or Irish red; Griotte, France and Spain; Echaillon, France; Formosa and Bougard, Germany: Brocatello, Italy; East Tennessee, red, brown, chocolate, and pink: rouge and garnet, France; Larancolin, France; red and pink, etc., from lake Champlain.

Green: Geneva, Alps, Campagna, and the Marie, New York, marble (columns in entrance to Art Museum). The red slate is used with the colored marbles.

Blue: Dover, Rutland, and Pittsford. In tilings, slate, red slate, Italian and Vermont white marbles, Lake Champlain black marble, and the Swanton red marble are largely used.

The monuments and statuary distributed through the parks and squares of the city have necessitated a considerable employment of stone. The Hamilton statue on Commonwealth avenue, of gray granite, is said to have been the first in the country made of granite (1865).

The soldiers' and sailors' monument, on the common, and that of Charlestown, are of granite from Hallowell, Maine. The Dorchester soldiers' monument, on Meeting-House hill, is of Gloucester red granite.

The Ether Monument group of statuary in the public garden is of Concord granite, as is also the Good Samaritan group of statuary; the figures on Horticultural hall are of Fitzwilliam, New Hampshire, granite; the pedestal of the Franklin monument, city hall, and the Warren statue, Bunker hill, are of Roxbury, Vermont, serpentine; the polished bases of the Winthrop and Prescott statues are of Jonesboro', Maine, red granite; also that of the Emancipation group. Quincy granite is used for the Adams, Washington, and many other bases; the soldiers' monument in Jamaica Plain is of Clark's Island, Maine, granite, with Quincy base: and the statue of Josiah Quincy, city hall, has a green verd-antique base.

One of the earliest applications of stone was in the city cemeteries. The principal old burying-grounds, those of King's chapel, Copp's hill, the Granary, Charlestown, and Roxbury, are much alike in the kinds of stone used. Some of the oldest tombstones are of porphyritic greenstone taken, presumably, from bowlders. The Welsh slate

was extensively used (often to be told by lines of color crossing the slabs) with American slate, foreign and American marble, and sandstone. In the King's Chapel ground may be noted the apparently early use of marble: a small tomb of shell marble reads 1702; the Winthrop tomb is supported by four marble columns. The Granary burying ground is much similar: red, green, and blue slate tombs have been used principally. The Franklin monument is of Quincy granite. At the large cemetery of Copp's hill we find much the same stones—red and greenish, Welsh, bluish American marble, yellow and red sandstone, and Vermont slate. In the Charlestown cemetery the John Harvard monument is of Quincy granite (1828).

The weathering of the stone in these old places is noteworthy. The Welsh slates, some of which have stood two hundred years, are often almost unaltered, looking very fresh; the greenstone tombs have also stood the weather well. In a slate slab at Copp's hill, having alternations of sandy layers parallel to the surface of the slab, one of these sandy layers has been eaten out, leaving the unsupported thin layer of slate to cave in; the slates are occasionally cleaned by the weather. The red and yellow sandstones, when standing upright, have almost always crumbled or scaled off, and the marbles have suffered. One case of this is a vertical slab at Copp's hill, about forty years old, of a coarse marble; below the ground it retains largely its original smoothness, but above the ground, on the northeast exposure, the action of the rain and atmosphere has dissolved out the cement of the grains of the marble, leaving the isolated grains sticking out like sandpaper; on the sheltered side there is a marked difference. Another large imported marble monument, some seventy years old, has weathered so that the shells embedded in the marble stand out in relief, and the stone is also covered with fine cracks, which, widening and admitting the black soot from the air, give it a peculiar appearance.

In the recent cemeteries of the city there has been an immense consumption of stone for monuments and curbing.

In Mount Auburn, in Cambridge, marble has been most used for monuments, and there are many fine pieces of statuary made from it: the Italian marble for the finer pieces, Vermont marble somewhat, and the pink Tennessee marble. Since the introduction of granite-polishing at our quarries there has been a great increase in the proportion of granite monuments. Quincy granite has been used since the opening of the cemetery, and there are many polished monuments of this stone. The light Mason, New Hampshire, granite is abundantly used here in polished monuments and curbing; also the Rockport granite and that of Concord. There are some fine monuments and tombs of Hallowell granite (the Sphinx and the Charlotte Cushman monument). Westerly granite has been somewhat used. Polished red-granite monuments are plentiful—Scotch, New Brunswick, and Maine. The Shap granite is used in a few cases; also some other granites. There are several tombs and monuments of the Somerville diabase, and a recently-polished one of diabase from Maine (Addison Point?). Both yellow and red sandstones have been used. The Winter monument consists of a large shaft of soap-stone coming, I believe, from a quarry in the east part of Andover forty years ago.

The weather shows its effects at Mount Auburn as elsewhere. Some of the old marble tombs have the roughened surface (by solution of the lime) previously mentioned; others, however, have stood as long without the same evidence of changes, especially the fine-grained marbles. In one tomb of a medium coarse white marble, in a course at the top part of the structure, the marble has disintegrated as follows: On the corner pieces and sides the marble cracks almost imperceptibly; along these cracks the cement of the grains (or some of the grains) is slowly dissolved out, leaving the coarse grains, and these finally crumble off in powder. As this continues, whole lumps are loosened and fall off, breaking into powder; in this way one of the corners has entirely crumbled to loose grains which may be taken up by the handful. The tombs made of the different granites have been slightly affected by the weather, consisting in a change of color: this is most marked in the Quincy; the light granites occasionally show a rusting of the feldspar. The diabase tombs have turned a rusty brown, the change apparently occurring in the black minerals (augite, mica, etc.), while the feldspar whitens. It is very noticeable here that grains of pyrite in the stone are generally bright, without patches of rust about them; one large shaft of the stone, finely bushed, has been little affected by the weather. Many of the red-sandstone tombs have exfoliated considerably; there is one curious case of a large tomb of this stone in which ivy had been trained up the face of the stone, but the continual peeling off of the layers afforded the tendrils no support.

Forest Hills cemetery.—The marbles are generally white Italian, bases often of Vermont marble. There are some very large tombs of marble; in one of them the Tuckahoe, New York, marble is used. There are a number of very beautiful monuments of the polished white Westerly, Rhode Island, granite; many of Concord, Quincy, and Rockport granite. The Randolph, Massachusetts, granite, with greenish spots, has been used in several polished monuments, and a gneissoid granite also. There are many fine examples of red granites—Scotch, Saint George, and Maine. A black granite (diabase) from Addison Point, Maine, has been recently used in a polished monument. The brownish-red Quincy is used in some beautiful shafts; also Shap granite; occasionally red and yellow sandstones; Rockport, Concord, Quincy, and other granites for curbing.

In Mount Hope cemetery there has been nearly a similar use of stone. The Odd Fellows' monument, with large carved granite figures, is of Hallowell granite with two courses of polished red granite; on the posts in front are two polished spheres of Quincy. The Army and Navy monument is a large structure of Concord granite; marble is used extensively as before—Quincy, Rockport, Concord, Mason, New Hampshire, Westerly, Randolph, etc. There are

several monuments of Aberdeen granite, New Brunswick red, etc. The Vinal Haven, Maine, reddish granite has been used in polished work, and Hallowell granite also. For curbing, Quincy, Rockport, Hallowell, Chelmsford, Milton, and Randolph granites. The red Tennessee marble in a few monuments.

At Woodlawn cemetery, in Everett, besides Italian, Vermont, and Tennessee marbles, Quincy, Hallowell, and others are used. There is considerable use of Vinal Haven granite; in one tomb there is the combination of Vinal Haven red, Spruce Head white, and black granite (diabase), all from Maine. Shap granite and the red granites are frequent. There is a shaft of dark soap-stone, probably from Andover.

WEATHERING OF STONES.—The climate of Boston must be one of the most trying ones in the country for building stones, as far as natural atmospheric causes are concerned; for in the winters there is a more or less frequent alternation of damp, rainy, and warm days with those of intense cold, while the rain-storms are violent; yet the deleterious effects of smoke and other products of certain manufactories are largely wanting; the changes in the stone are hence due to the character of the stone itself, and to the defects in it; at the same time most of the stone buildings have not stood long enough to develop a marked change in the stone.

The granites have generally been affected by chemical change alone in some of the constituent minerals, as is evidenced by a change of color—an effect of a higher degree of oxidation of the iron; but they have generally not crumbled. The Quincy granite, since it is found in the buildings that have stood longest, and since it contains a dark feldspar, shows often the signs of change. The stone is of many shades: blue, greenish-blue, pink, reddish, brown-gray, and grayish black, these being the colors of the feldspar, the mineral in which is found the change, if there be any. This turns liver-brown, rusted-red, yellow or white; often the whitening of the feldspar, with the white look of the quartz, causes the bush-surface to appear almost white. The hornblende seems less frequently affected, turning green and rusty brown. Some of the Quincy stone has stood for years without any very noticeable change of color. Perhaps the Boston custom-house shows best in one building the differences in the weathering, the color remaining unchanged in some cases, in others having become a deep brown, differing in the separate blocks, and even in different ends of the same block.

The light granites (Hallowell, Concord, etc.) have naturally not changed much in color, nor have the buildings been standing long. The principal change observed seems to consist in a dull whitening of the feldspar, and an occasional rusting of that mineral to a yellow color. The white granite from the vicinity of Chelmsford, which was used so extensively in Boston fifty to sixty years ago, shows almost universally in the old buildings a change in the feldspar to a honey-yellow; this is perhaps in part due to the fact that almost all this granite was then quarried from loose bowlders, and of inferior quality to that obtained from ledges. This can be seen in the Massachusetts general hospital, the central part of which—erected in 1818–'21, of stone derived presumably from bowlders—shows the yellow weathering, while the wings, of stone quarried in 1846, are almost unchanged (the garnets scattered through some of the old stone have not changed); part of this difference may be due to the difference in the date of erection.

A red granite from Gloucester has not rusted and faded, but it has been but little used in the city.

The marble buildings have not been standing long and do not generally show a perceptible change, except in the blackening and roughness of the surface. The veined ornamental marbles when exposed out of doors have generally suffered by the removal of the softer parts of the veins. This is notably shown in the pedestals, of veined serpentine marble, of the two statues in front of the city hall—one erected only four the other some twenty-five years ago. The calcite veins in the serpentine have become roughened by the weather, and cracks, which widen so that pieces fall out, often form along them; this is much more marked on the flat surfaces. The green Roxbury, Vermont, serpentine, in consideration of its twenty-five years' exposure, has stood the weather well. The green serpentine used in one building has crumbled on the surface like sand.

The red and yellow sandstones used so extensively in the city vary in character so greatly, even in the same building, that it is difficult to make general statements. Many years back a great amount of red sandstone from the Connecticut valley and elsewhere was brought to Boston, and can now be seen in many of the older brick houses: it was generally coarsely stratified, and, moreover, was laid up with the stratification or layers perpendicular instead of horizontal, the consequence of which has been a frequent cracking, opening, and falling off of pieces. Where sandstone pillars were thus made, it can often be seen how the split began at the bottom, where the free edges of the layers were exposed and worked up. The introduction of better and more homogeneous stone from the quarries of the valley, from New Jersey, and from the provinces, and greater care by the builder, have largely done away with this; yet still cases of scaling off are seen. The other change in the red sandstones has been in the depth of the red color.

The yellow sandstones of different shades from New Brunswick, Nova Scotia, and northern Ohio have been very variable in their character, the same quarries furnishing apparently both good and bad stones. None but homogeneous sandstones of this class have been in general use, and there have been two main changes by weathering, exfoliation, and falling off of pieces, owing to incoherency of the particles, giving the stone a rough appearance; and also rusting of the iron in the stone. The latter has been most noticeable, and occurs either by a uniform change of color in the whole block of stone or only in patches; or else there are parallel layers in the stone, some of which rust while others do not; and consequently when the face of the stone is cut across these

layers we have rusty bands crossing it at intervals. This can be seen very markedly in some of the buildings of the city, and poor selection of the stone must be partly the cause. In many buildings, however, the yellow sandstone has stood unchanged: a good example of this is the Washington building, of Nova Scotia stone, erected over twenty years ago.

Occasional changes of color in slated roofs are observable in the city, especially in the green slate, which often changes to a yellowish red. The black slates have rusted, especially in buildings where cheap slate has been used, and the purple slate changed to reddish; but these seem rare. The Bolton mica-schist, having hard quartziferous tongues in the softer rock, has worn down by the passing feet, leaving these tongues in relief in peculiar shapes.

Movements of the ground have occasionally occurred, especially in the older streets, cracking the sills, and in some cases two motions in opposite directions appear to have affected one block of stone, cracking it twice.

BRIDGEPORT, CONNECTICUT.

Portland brownstone is the material usually employed in Bridgeport for the better class of stone construction. Gneiss from Greenwich, and granite to a limited extent, are used for the same purposes. The foundations and underpinnings are of gneiss from the local quarries. A long line of wooden wharves along the water front is backed with stone walls of very rough masonry built of the gneiss from local quarries. The west approach to the Central bridge across the harbor is faced with cut stone with a dressed granite coping. The intermediate piers and draw-pier are built of the same material. The approach is 300 feet long and 41 feet wide. The railroad draw-pier and east abutment are built of Greenwich stone. Bridgeport harbor and Black Rock harbor, both within the city limits, have each an extensive breakwater, the first of stone quarried a little north of Lyme on the Connecticut river, a quarry not now operated. There is a substantial wall, over half a mile in length, of stone from local quarries. The streets are but little paved with stone; the material used is trap-rock from New Haven. Many of the sidewalks are paved with North River blue-stone, and the curbs are of the same material, with some gneiss.

BURLINGTON, IOWA.

Most of the limestone quarried in Burlington disintegrates and exfoliates on protracted exposure to the weather and to the action of frost. It appears, however, to be tolerably durable when protected as in underground work. This imperfection of the stone, the cost of transporting better building stone, and the cheapness of lumber and brick—the city having access to extensive lumber regions on the Mississippi river, which is the natural route of communication with the northern pineries—have very much restricted the use of stone. The banks of the Mississippi in this region are covered with löess or rearranged drift material suitable for the manufacture of brick. This has also had its effect in preventing the use of stone as a building material. There are no natural obstacles to the use of heavy building materials. The substratum which is found at a limited depth being formed more or less with compact limestones, the glacial drift and calcareous clays forming the superficial soil are themselves so compact and firm as to largely obviate the necessity of paving the streets. The city sewers are the most important works in which stone is employed. They are mainly constructed of limestone quarried within the city limits, either by quarrymen in temporary quarries, or by contractors in grading streets. There are some sidewalk pavements of limestone flagging from Sagetown, Illinois, and Mount Pleasant, Iowa.

CAMBRIDGE, MASSACHUSETTS.

The materials employed for the better class of construction in Cambridge are Quincy, Rockport, and Concord granites, Somerville diabase or trap, Somerville slate, and Roxbury conglomerate. The foundations are of slate from the Somerville quarry, and diabase from the same place, with some granite from Rockport and Quincy. The underpinnings are built of granite from Rockport, Concord, and Spruce Head, in Maine. The soldiers' monument on the common is built of Mason, New Hampshire, granite. For posts, the Somerville diabase, and Rockport, Quincy, and Concord granites have been extensively used. In the sewers the Somerville slate has been employed for the sides, and slate and granite for the top. For the stones at the entrance to the catch-basin Rockport granite and North River blue-stone have been used. There are no stone bridges of large size. In the sea-walls about East Cambridge the Somerville diabase has been largely used. There are about a hundred miles of graded streets in this city, and about 2 miles are paved with granite chiefly from Quincy; three-quarters of a mile is paved with cobble-stones. A few of the sidewalks are paved with the North River blue-stone; the curbs are of Rockport granite with a very little blue-stone.

CAMDEN, NEW JERSEY.

The materials used for stone construction in Camden are, for foundations and underpinnings, gneiss from the quarries near Chester, Pennsylvania, and sandstone from Greensburg, New Jersey. For the better class of stone construction serpentine from Delaware county, Pennsylvania, Vermont marble, Trenton freestone, Connecticut brownstone, and Ohio sandstone are used. Philadelphia pressed bricks are the material chiefly used in the walls

of buildings. The Ohio sandstone, used to a limited extent, is well esteemed here. Berea, Ohio, stone was used in the construction of the court-house. The serpentine tends to crumble and split in winter, and breaks under heavy pressure. The streets are largely paved with stone, and in the portions which are paved with rectangular blocks Connecticut stone is used. Much of the pavement is cobble-stone from the Delaware river above Trenton, but there is but little stone sidewalk pavement, brick being the material mostly used for sidewalks. Slate from Lehigh county, Pennsylvania, is used to some extent for this purpose, and also trap-rock quarried near Lambertville; the curbs are of Connecticut granite.

CANTON, OHIO.

Canton is situated but a few miles from the important and extensive stone quarries located on the Massillon sandstone at Massillon. It is almost the only material used in stone construction in this city. In a few instances, where very fine carving and finishing were desired, Berea and Amherst sandstones were used, as the Massillon stone is too coarse-grained to answer well for these purposes. There are but four or five buildings in Canton entirely of stone; a few have fronts of stone as high as the second story, and quite a number have much stone in their composition in the way of corners and heavy caps and sills. The stone sidewalk pavement is almost entirely of Berea sandstone. The Massillon sandstone is not often found in layers of convenient dimensions for paving flags. The streets are largely paved with stone, cobble-stones from the drift near the city being used.

CEDAR RAPIDS, IOWA.

The stone from the local quarries is practically worthless for purposes of construction, and the freight is such on the Anamosa limestone as to render it too costly to compete with brick and timber. Much of the Anamosa material is objectionable on account of lack of strength and durability. The Farley stone is better, being more uniformly good, but the cost of shipment prevents its extensive use. Some stone has been moved from near Mount Vernon to Cedar Rapids within the last year or two. In some cases builders have placed Anamosa limestone on edge in caps, sills, corners, etc., of brick buildings with the result, which might have been foreseen, of causing its gradual exfoliation and separation into extremely thin laminæ. Much of the stone is indeed unfit for curbstones on account of its tendency to exfoliate on exposure. The piers of one or two bridges across the Cedar river are of limestone from Anamosa. Magnesian limestone of Niagara age, quarried at Stone City, Jones county, Iowa, was used in the construction of the Carpenter block, Third Ward school-house, city jail, and post-office. There are no other important stone structures. Caps, sills, water-tables, etc., are of Anamosa limestone; the bases for monuments, and a few curbstones, are from Farley, although the Anamosa limestone is also used to some extent for these purposes. The streets are not paved; there are a few blocks having stone sidewalk pavements of Anamosa limestone; curbs are of Anamosa and Farley limestones.

CHATTANOOGA, TENNESSEE.

In the city of Chattanooga stone is just coming to be used to a considerable extent for purposes of construction. In the valley where the city is located there are two formations of Lower Silurian age, the Nashville and Trenton, and the Knox or Quebec dolomite. The latter has been used to some extent, but is rather cherty, though some of its courses approach marble in quality. The stone chiefly used is that classed by Professor Safford as the Maclure limestone, from its large fossil, *Maclurea magna*. There are several quarries of this stone in the vicinity of the city. The old quarry near the Chickamauga station, of what was called by the soldiers Chattanooga marble, is in Georgia, and is objectionable on account of having seams in it which cause it to disintegrate by the action of frost.

The pillars of the Union depot are built of this stone, but in additions which were made to the building the material was rejected and that from a local quarry was used. The growth of Chattanooga has been very rapid, and brick has been chiefly employed for fronts, but stone is growing daily more and more important as a material for construction. The pillars and ornamental parts of the court-house are of Knoxville marble, the basement of local stone. The only private residence entirely of stone is of a common limestone from local quarries. This stone is largely used for steps, caps, sills, and other trimmings; it is also much used for foundations. The front of the old post-office, now occupied by the offices of the Cincinnati Southern Railroad Company, is of a yellow sandstone from the line of the Alabama Southern railway. It is soft when first quarried, and easily wrought, but becomes hard on exposure and resists the action of the weather quite well. It is easy to get good foundations in Chattanooga, as limestone usually lies near the surface. There are, however, marshy places that have been filled in, but a few feet of digging reaches the stone. Rolling-mills and blast-furnaces all have solid foundations of stone. The front of the First National bank is built from stone from a local quarry. The quarries from which material for foundations and underpinnings are obtained are situated from 2 to 8 miles from the city. The streets are macadamized with this same material, and there is some stone sidewalk pavement of limestone from local quarries, with curbs of the same material. Piers of all the bridges in the vicinity are constructed of this limestone.

CHELSEA, MASSACHUSETTS.

There are only two buildings in Chelsea entirely of stone (the material used is what is called "mortar-stone"), and two have stone fronts. Those entirely of stone are built of a calcareous rock found in the vicinity. There are two fronts of Cape Ann granite. The foundations and underpinnings are of Cape Ann and Quincy granite. But few of the streets are paved with stone, and the material used is Cape Ann and Quincy granite. The sidewalks are not paved with stone; curbs are of Cape Ann granite.

CHESTER, PENNSYLVANIA.

The only stone exposed in the vicinity of Chester is the gneiss, on which there are several quarries of considerable importance; these quarries furnish almost all the stone for building purposes in the city. In the bridge abutments, however, some Port Deposit gneiss is used in combination with the gneiss quarried in the vicinity. The streets are paved with stone to a limited extent, the material used being cobbles from the Delaware river and rubble from the gneiss quarries in the vicinity. Stone is but little used for sidewalk pavements, brick being ordinarily employed for this purpose. In such sidewalks as are paved with stone the North River blue-stone is used.

CHICAGO, ILLINOIS.

By J. S. T. Batchen.

LIMESTONE.

The principal stone used in construction in Chicago is the Niagara limestone. The city is supplied with this stone from the various quarries located around Lemont, Cook county. It is brought to the city by means of canal-boats and is unloaded at the docks of the various quarry companies by means of horse or steam-power derricks. It is also brought from Bedford, Indiana.

The material is used as building, dimension, and rubble stone. The first is used in buildings as cut stone, and is of the best quality. The dimension stone is of an inferior quality, yellowish, and generally harder than that used for building purposes, and is used for vault covers, flagging, curbing, and sawed window-sills; roof-coping is made from a variety of this stone varying from 1½ to 3 inches in thickness. This quality of stone frequently contains nodules or layers of flint, which occasion some trouble in working; in other places it assumes a siliceous, even flinty, character. This and its yellowish color do not, however, lessen its value for the above-named purposes.

The stone used for rubble is generally of the second class, although frequently first-class stone too small for building purposes is used. This quality is the only stone used in the city for foundations. The stone when sold to contractors is in large blocks or slabs; these are broken into suitable pieces for cutting by means of hand-churn drills, with which holes 3 or 4 inches in depth and from 4 to 5 inches apart are made in the stone, and the separation is made by use of wedges and feathers. Frequently the stone is stunned here and there by the pressure of the shoulder of the steel wedges. This part, although generally seeming as perfect as the rest of the stone, under atmospheric influences frequently scales or drops off and is condemned, when it is really the fault of the handling.

The Lemont limestone is known to some architects as Joliet limestone, but with no valid reason, as, although there are a number of limestone quarries at Joliet, the stone which supplies Chicago is from Lemont, Cook county, excepting occasionally when cut-stone contracts are let to the state penitentiary, when the stone used there comes from that locality. In letting contracts the stone of any particular quarry is seldom specified, but is referred to as the best quality of Joliet or Lemont limestone; the stone from the different quarries differs very slightly, if at all, that from several of the quarries having a yellowish color. The stone used in the construction of the county part of the court-house is from the lighter-colored stone.

The limestones of Cook county harden upon exposure to the atmosphere for any length of time, and are easiest worked when newly quarried. The stone also becomes slightly yellowish with age, the softer varieties being always the whitest, while those which have a tendency to hardness have generally a slight yellowish or cream color. Any stones which are very hard to work are made much softer by soaking them in water for some time, or even by throwing water on the stone. The Lemont quarries furnished the first stone used in construction in this city, and for the length of time it has been in use seems to stand atmospheric influences and sudden changes of temperature very well, although the stone of some buildings has a tendency to scale off here and there, more especially the stone cut entirely by hand in structures which have been built for some length of time, which may probably be accounted for on the following hypothesis, viz: the stone when given to the workmen to dress, after being drafted is pointed, then axed, and then bush-hammered, the two latter tools weighing from 8 to 12 pounds, and when used probably striking a blow of from 150 to 200 pounds at least, so that the part on which these tools have been used, although seemingly as perfect as the rest of the stone, is probably stunned to

the depth of from one-sixteenth to one-eighth of an inch, and even as deep as one-quarter of an inch, which only requires time and atmospheric influences to cause it to scale or drop off, showing a ragged surface; this theory has been strengthened by the fact that stones in which the face has been sawed by machinery never show the slightest tendency to scale, while those dressed with tooth-ax and bush-hammered generally scale off, though sometimes very slightly. There are in this city about 40 cut-stone yards, of whom about one-half use machinery, as saws and rubbing-beds.

This limestone is never polished. The slightly-yellowish color which the stone takes after years of exposure, and which the poorer varieties, those which are used for vault covers, flagging, and window-sills, have when quarried, are probably caused by sulphide of iron, this brilliant mineral being frequently found in the natural seams and crevices, and between the different strata of stone; light greenish veins are frequently noticed in the stone similar to the veins in white marble.

Quarries of this stone (Lemont limestone) at Bridgeport and along the western city limits produce large quantities of excellent quicklime.

In laying the water and sewer pipes in this part of the city the rock has frequently to be blasted to enable the pipes to be laid to a sufficient depth to protect them from the frost. About two-thirds of the stone used for sidewalks is dressed by means of steam-planers. A large amount of other stone-cutting, such as moldings on cornices, etc., is done by means of machinery.

Oolitic limestone.—Blue oolitic limestone from Bedford, and a buff-colored oolitic limestone from Avoca, Lawrence county, Indiana, have been used somewhat in the city within the last few years. When stone was selected for the construction of the city part of the new court-house, the choice was finally awarded to this stone, and its being used in the city hall immediately led to its use in a number of other buildings in the city. The buff oolitic limestone from Avoca is not used so frequently as the blue oolitic from Bedford, in the same county, but this may be accounted for by the fact that the latter was used in the construction of the new city hall. When first built the structures in which either of these two stones (blue or buff oolitic limestone) were used looked very well, but in a short time they became dark and dirty looking, more especially the buildings in the business or commercial part of the city.

Sandstone.—The sandstone known by the general name of Waverly sandstone or Ohio freestone is brought to the city from the various quarries at Berea, Columbia, Berlin, Amherst, Waverly, and other places in the state of Ohio, and is used in some of the largest structures in the city. That from Berea and Amherst, of a bluish-gray color, is very largely used in the mills and factories of the city for grindstones. What is known as blue Columbia sandstone, from Columbia, Ohio, although furnishing one of the finest building stones used in the city, is remarkable for the rapidity with which it will become stained with rust (ferric oxide). In sawing the stone into slabs the greatest care is necessary; the sawing of the blocks is generally begun early in the day, so that they can be sawed entirely through without stopping; when taken from under the saw-blades the cut which the saws have made is well washed with clean water. When the stone was first used in the city, or when sawed by parties unacquainted with this peculiarity, the saws were often allowed to remain at rest between the slabs over night; when the slabs were removed and opened up, a stain of iron rust the full length and breadth of the saw blade, and which penetrated the stone from one-third to one-half of an inch, was found, which could only be removed by cutting out the part stained. The laying of a wet chisel or any piece of wet iron on the stone for a few hours is sufficient to cause a similar stain.

Sandstone from Buena Vista, Ohio, has been used in the construction of the Chicago custom-house, and for a number of other buildings in the city. In the custom-house the stone contains large numbers of spots of iron pyrites, resembling those found in Aux Sable stone. They are removed by cutting out the spot with a chisel and then filling the cavity with a mixture of stone dust and liquid shellac, which very soon falls or crumbles out, leaving the original cavity. The stone also stands exposure very poorly, splitting or falling off in large scales or flakes and crumbling away until the original sharp outline is completely lost; the scales which fall off have the peculiarity of being exactly the same on the upper and lower sides; and should the stone be what is known as droved, the scale follows exactly the depressions which the chisel has made. Several attempts have been made to coat or paint the stone with some composition which would protect it from the air, but have not been very successful.

Sandstone from Aux Sable, Grundy county, Illinois, is used somewhat for building purposes. It is of a light grayish-white color, and is very easily dressed—in fact the easiest of any used in the city. It contains large quantities of small scales of mica. The stone contains sometimes iron pyrites; the iron under atmospheric influences, and especially when wet, causes the stone to stain with iron rust wherever the pyrites appear; if the stone is protected from the action of water and air no rust stain appears.

A number of buildings have been constructed in which this stone is used, together with Lemont limestone, as, for instance, caps of limestone and the keystone of Aux Sable sandstone. The contrast afforded by the two stones has a very pleasing effect. Aux Sable stone, when crushed to a fine powder and mixed to a thick dough with water, forms a very good fire-brick lining for furnaces, etc.

Brown or mottled sandstones, from Lake Superior, Michigan, were introduced about 1870. The stone is generally of a rich, deep, reddish-brown color, and may be favorably compared with the brown freestones of Connecticut and

New Jersey. There are, however, some exceptions, the stone of some quarries being very coarse and gritty, and sometimes containing flinty pebbles varying in weight from a few grains to two or three ounces; these are generally very loose, and when struck by the chisel in cutting the stone fly out, leaving a cavity which has to be filled with a mixture of brownstone dust and liquid shellac. The variety containing these pebbles also contains numbers of cavities or pockets filled with clay, iron ore, or a reddish clay, which with water forms a reddish mud. These defects are only found in stone from particular quarries, and can be altogether avoided. The quarries which principally supply the city are those at Marquette and at L'Anse, Michigan; the stone since its introduction has been very generally used and is well liked. A peculiarity of Michigan brown sandstone is the fact that the stone from almost every quarry is spotted here and there with white spots (generally round), varying in size from the size of a small pea to 12 or 18 inches in diameter, though the latter are not very frequent. Various means have been tried to color the spots the same as the rest of the stone, but without success, as whatever is used is soon washed out when exposed to the weather. These spots appear to be of exactly the same composition as the rest of the stone, with the exception that they are uncolored and appear as if they had been touched by a drop or globule of some oil which had prevented the adhering of the coloring matter which had colored the rest of the stone: in this they resemble that which takes place in obtaining oleographs of the different oils, as in Tomlinson's cohesion figures.

Within the last two or three years stones as regularly spotted as possible to obtain have been used as a building stone, which gives the building a mottled red and white appearance, which looks very well. The spots seem to stand as well as the colored parts of the stone.

Brown sandstones from Portland and Middlesex, Connecticut, and from New Jersey, are used in a number of instances but not in large quantities. Those of Michigan are much more used. The cost of working all the sandstones used in Chicago during frost is double what it cost to dress the same stone during warm weather—as the stone which, during warm weather, is a freestone and very easily dressed, under the influence of frost becomes hard, dense, and tough, becoming like lead. Should the weather be very cold the cutting of the stone is entirely discontinued. No matter how dry it may be the advent of frost causes it to become harder and tougher in working. The frost does not appear to have any permanent effect, as on the return of warm weather it again resumes its normal appearance. Machinery is not used at all in the dressing of sandstone excepting to saw it into 4-, 6-, or 8 inch slabs.

GRANITES.—Granites are pretty generally used for ornamental purposes, as for columns, pilasters, monuments, and in one or two instances for sidewalks; but there is only one building constructed entirely of granite in the city—that of the Chamber of Commerce—and one other constructed with granite front. Those principally used are blue or grayish granite from Aberdeen, and a reddish granite or syenite from Peterhead, Aberdeenshire, Scotland; granites largely used for monuments and columns and caps from the Chicago and Wisconsin Granite Company, Waterloo, Jefferson county, Wisconsin; the Westerly Granite Company, Westerly, Rhode Island; from the quarries at Fox island and Hallowell, Maine, and from Henrico county, Virginia, and Moundville, Marquette county, Wisconsin. None of these granites are used in any large quantity, but only here and there, excepting those of Fox island and Hallowell, Maine, which are used in the Court-house and the Chamber of Commerce buildings.

MARBLES.—The marbles of Rutland, Vermont, are largely used in interior work, as mantels, tiles, etc., together with red marbles from Tennessee, Mexican onyx, Belgium black from Brussels, and several marbles from Italy.

All the prominent buildings of Chicago have been erected since the fire of October 9, 1871, and are therefore comparatively new.

In using the stone from the Lemont, Cook county, quarries it is brought to the city during the summer in large quantities, so as to be seasoned before the approach of frost. Thousands of dollars' worth of this stone are lost annually to contractors who have purchased stone which has been quarried too late (or what is known to the trade as greenstone), and which a sudden sharp frost causes to crack and burst in every direction, and making it worthless for any purpose. When the stone is once seasoned no amount of cold has any effect on it. In some instances if the stone is not disturbed till warm weather the cracks appear to close up.

STONE WORK OF SOME OF THE PROMINENT PUBLIC AND PRIVATE BUILDINGS.—The court-house consists of two parts, the county part and the city part. The county part is chiefly constructed of Lemont limestone. The columns and other granite work are of Fox Island, Maine, granite. In the construction of the city part Bedford, Indiana, oolitic limestone was used; the foundations are of Lemont limestone; columns and other granite work of Fox Island, Maine, granite. The interior ornamental stone-work is chiefly of marble from Rutland, Vermont. Cook County hospital is constructed of Lemont limestone. The custom-house and post-office building is of Buena Vista freestone from the quarry located near the Ohio river, about 100 miles above Cincinnati; there were used 467,445 cubic feet of rough Buena Vista stone; there were used in the pier foundations 48,731 cubic feet of Lemont limestone; foundations of Lemont limestone; the stone used for vault covers and sidewalks is Maine granite. John B. Sherman's residence is of blue sub-Carboniferous sandstone from Columbia, Ohio; foundations of Lemont limestone, with polished columns of granite from Quincy, Massachusetts. The Chamber of Commerce building has a superstructure chiefly of granite; three fronts are of Fox Island, Maine, granite, and the rear wall is of Hallowell granite; foundations of Lemont limestone. The Palmer house is of Amherst, Ohio, sandstone; Lemont

limestone foundations. The Mackin hotel is of Amherst, Ohio, sandstone; foundations of Lemont limestone. The Grand Pacific hotel, on the block bounded by Clark, Jackson, Quincy, and La Salle streets, has three fronts of Amherst, Ohio, stone; foundations of Lemont limestone. The Sherman house, corner of Clark and Randolph streets, is of sandstone from Kankakee, Illinois, which is injuriously affected by reason of the iron pyrites in its composition; foundations of Lemont limestone. The First National bank has marble counters and floor-tiling of red Tennessee and Rutland, Vermont, marble; in the superstructure blue oolitic limestone from Bedford and buff oolitic sandstone from Avoca, Indiana, were used; the foundations are of Lemont limestone; the granite work is of Jonesboro', Maine, red granite. Saint Luke's hospital: blue oolitic limestone from Bedford, Indiana; foundations of Lemont limestone. Saint Paul Universalist church: Lemont limestone. West Side water-works: cut stone is Bedford, Indiana, oolitic limestone; foundations of Lemont limestone. North Side water-works: rock-faced with Lemont limestone; foundations of same material. Academy of Music: Lemont limestone. Northwestern Railway depot: sandstone from a quarry belonging to this road on lake Huron was used; foundations of Lemont limestone. Haverly's theater: Lemont limestone. Depot of Chicago, Rock Island, and Pacific, and Lake Shore and Michigan Southern railroads is rock-faced with Lemont limestone; foundations of same material. The Union League club-house: brown sandstone from Springfield, Massachusetts; the underpinnings are of the Bedford, Indiana, blue oolitic limestone; foundations of Lemont limestone. Central Music hall: Lemont limestone; foundations of same material; the interior ornamentation is of Rutland, Vermont, marble and Mexican onyx; the polished columns are of granite from Red Beach, Maine, and Quincy, Massachusetts. In the Stephen A. Douglas monument the foundation and tomb, the coping, sidewalk, and terrace wall are of Lemont limestone; the pedestals and other granite work of Fox Island, Maine, granite. The armory of First Regiment, I. N. G.: Lemont limestone. Office of the Chicago, Burlington, and Quincy Railroad Company, corner of Franklin and Adams streets: Bedford, Indiana, blue oolitic limestone; foundations of Lemont limestone; sidewalks of the latter material; white Italian statuary marble, black marble from Brussels, Belgium, and red Tennessee marble were used. Calumet club-house: Bedford, Indiana, limestone; foundations, Lemont limestone. Chicago university: rock-faced with Lemont limestone; foundations of the same material. A. G. Byram's residence: Avoca, Indiana, oolitic limestone; foundations of Lemont limestone. M. L. Wilson's residence: Lemont limestone; foundations of same material. Block of residences from 1200 to 1210 State street: Amherst, Ohio, sandstone; foundations of Lemont limestone. Store 302 west Madison street: Buena Vista, Ohio, freestone; foundations of Lemont limestone. Store on Wabash avenue, near Van Buren street: Lemont limestone. Residence, Adams and Lincoln streets: Lemont limestone. Residence corner of Rush and Illinois streets: Berlin, Ohio, sandstone; foundations of Lemont limestone. Wickerson residence: Amherst, Ohio, sandstone; foundations of Lemont limestone. Residence, 549 and 551 west Van Buren street: Lemont limestone and granite from Peterhead, Aberdeenshire, Scotland; foundations of Lemont limestone. Residence, Adams street, near Lincoln street: Lemont limestone. Williams building, Wabash avenue and Monroe street, Amherst, Ohio, sandstone; foundations of Lemont limestone. Taylor building, 146 Monroe street: Bedford, Indiana, oolitic limestone; foundations of Lemont limestone. Adams building, Adams street and Wabash avenue: Amherst, Ohio, sandstone; foundations of Lemont limestone. Residence of C. P. Libby: brown sandstone from Marquette, Michigan; foundations of Lemont limestone. Residence of W. F. Storey, Chicago *Times*, in process of construction: blue marble, Pittsford, Vermont; foundations of Lemont limestone. Boise block, northeast corner of State and Madison streets: partly of Lake Superior brownstone and partly of stone from the bed of Oswego river, New York; the two kinds of brown sandstone from these localities, so widely distant from each other, are so much alike that they are used together indiscriminately; they are both of Potsdam age; foundations of Lemont limestone. B. P. Moulton's residence, Nineteenth street and Prairie avenue: brown sandstone from Middlesex, Connecticut: foundations of Lemont limestone. Potter Palmer's residence: ashlar of brownstone from Portland, Connecticut, and granite from Marquette county, Wisconsin: trimmings of Amherst, Ohio, sandstone; underpinnings of limestone from Trinity bay, Canada; foundations of Lemont limestone. Honore block: Lemont limestone; Howland block: Cleveland, Ohio, sandstone; foundations of Lemont limestone. Merchants' building, northwest corner of La Salle and Washington streets: Buena Vista, Ohio, stone; foundations of Lemont limestone. Dore block: Buena Vista, Ohio, sandstone; foundations of Lemont limestone. Reid block: Lemont limestone. Union building, southwest corner of La Salle and Washington streets: sandstone from Au Sable, Grundy county, Illinois; foundations of Lemont limestone. Speed block, on Dearborn street, between Madison and Washington streets: Bedford, Indiana, oolitic limestone; foundations of Lemont limestone. Booksellers' row: Lemont limestone. Montauk block: Bedford, Indiana, oolitic limestone; foundations of Lemont limestone. Grannis block, Dearborn, between Washington and Madison streets: Bedford, Indiana, oolitic limestone; foundations of Lemont limestone; columns of gray granite from Quincy, Massachusetts, and red granite from Peterhead, Aberdeenshire, Scotland. Borden block, northwest corner of Dearborn and Randolph streets: Berlin, Ohio, sub-Carboniferous sandstone; foundations of Lemont limestone. Ryerson building, corner of Washington avenue and Adams street: Bedford, Indiana, oolitic limestone; foundations of Lemont limestone. Schufeldt residence, Dearborn street and Lincoln park: green serpentine from Chester county, Pennsylvania; foundations of Lemont limestone. This is the only building in Chicago constructed of Chester county, Pennsylvania, serpentine.

CINCINNATI, OHIO.

Cincinnati is built on ground of the great limestone formation which takes its name from this city, and which is sufficiently durable for foundations when kept below the surface of the earth. In some places in the city the ground is unfavorable to heavy building, as the shales in the hill slopes give way under heavy pressure. For the better class of stone construction sandstone from Portsmouth and the Amherst and Berea quarries, and limestone from Dayton from different points in Indiana, and from the home quarries, and granite from Maine and from Missouri are used. For foundations and underpinnings, beside the limestone quarried in the vicinity, some limestone from Dayton and from points in Indiana, and freestone from the vicinity of Portsmouth, are used. The abutments of bridges over the Ohio river are built of limestone from the home quarries and from Dayton, from points in Indiana, and sandstone from the vicinity of Portsmouth. The streets are largely paved with cobble-stone, but many of the streets and roadways are macadamized with the native limestone. There is considerable stone sidewalk pavement, and the material used for this purpose is the freestone from the vicinity of Portsmouth; also, to a limited extent, limestone from the home quarries and from Dayton, and of late years the remarkably even-bedded limestone of the Helderberg formation from Greenfield, in Highland county, has been largely used. The following are some of the principal structures in Cincinnati, with the stones used in their construction: In the custom-house, limestone of Niagara age and granite from Missouri and from Vinal Haven, Knox county, Maine, were used; in Pike's opera house, the Gibson house, and Shillito's block, freestone from Scioto county was used; in the Sinton building, Trust Company's bank, and Johnson's building, freestone from Rockville, Adams county, was used.

CLEVELAND, OHIO.

Cleveland is situated within easy reach of all the celebrated quarries of the Waverly sandstone in northern Ohio, and nearly all of its stone construction is of this material. The Amherst sandstone is used almost exclusively for the superstructure of stone buildings. The Euclid blue-stone has not been used in any important structures. In the construction of the city hall, sandstone from Independence, Cuyahoga county, was used: Beckman's buildings, Exchange buildings, hotel Madison, Bronson's block, and the court-house, are of Berea stone. The soldiers' monument is of granite from Woodbury, Washington county, Vermont. The Amherst stone is deemed here the best for superstructures and trimmings of buildings; the Berea stone best for bridge-building purposes; the east Cleveland building stone best for foundations and underpinnings; the Euclid blue-stone best for sidewalk paving; the Medina sandstone, from Medina, New York, is used in a few structures; foundations and underpinnings are of local sandstones. The streets are largely paved with stone, and the material used for this purpose is the Medina sandstone. The sidewalks are nearly all paved with stone, and the material used is blue-stone from Euclid and Newburgh; also to some extent sandstone from Berea. The stone commonly used for curbstones is the Medina sandstone, while bridge piers and abutments are mostly built of Berea sandstone. The stone used in the construction of the Cleveland viaduct is from the Berea quarries.

COLUMBUS, OHIO.

Columbus is built mostly on ground made by the glacial drift, which covers a considerable portion of the surrounding country. The greater portion of the site of the city is on ground well elevated above the Scioto river, affording facilities for drainage, and the drift formation furnishes cobble-stones for street pavements and gravel for roadways. That portion of the site, however, which lies west of the Scioto river is on a low, alluvial bottom, but little elevated above the surface of the river, and protected by levees which prevent its inundation when the waters of the river are high. In the extreme western portion of the city limits the Corniferous limestone forms a rather abrupt bluff, and on it are located extensive quarries, where most of the material used for all building purposes in Columbus is obtained. This material was used in the construction of the Ohio state-house, and in the colonnade surrounding the building the columns are constructed of blocks from a course of this limestone which comes from near the bottom of the ledge. The walls of the Ohio state prison are also of this stone. The sandstone from the Waverly formation is used to some extent, and the material is obtained at Berea, near Portsmouth, Black Lick, and Reynoldsburg. The Dayton limestone of Niagara age is used in a few instances, chiefly for trimmings. Saint Joseph's cathedral is built of stone from the Waverly conglomerate, quarried near Lancaster, and some of the material obtained from the Newark quarries is also used. It is worthy of remark here that there are three formations, the exposures of which pass north and south within a few miles of Columbus, all being important sources of building material. Beginning at the east, appears the Waverly conglomerate, next westward the lower Waverly. There is then an interval of several miles of Hudson shales, after which, immediately west of Columbus, the great ledge of Corniferous limestone is exposed, of good quality for general building purposes, and readily accessible to the city. Among the other prominent stone structures in Columbus are the Ohio blind asylum, built of Waverly sandstone quarried near Reynoldsburg, 10 miles east of Columbus; Trinity church and the Kelly residence are of Waverly sandstone from Piketon, Pike county; First National Bank building, McCune block, and Nuthoff block are of Waverly freestone from Rush township, 12 miles from Portsmouth; and the basement and trimmings of the Ohio state university are of Amherst freestone.

CONCORD, NEW HAMPSHIRE.

The seven stone buildings in Concord are constructed of the well-known Concord granite, the quarries of which in the vicinity of the city furnish nearly all the material for stone construction at this place. All the buildings erected of stone in Concord and in Nashua are in excellent condition—no discoloration or decomposition, though the joints in the Concord quarries carry a slight discoloration down to the lowest depth. The substratum is occasionally rock, but usually sand. Brick is the most common material used for building purposes in these cities. The fact that stone construction is more expensive than that of brick or wood rules it out of use here, except for some public buildings. The following is a list of the stone structures in Concord: The state-house, state prison, church in West Concord, Ward & Humphrey's storehouse, two dwelling-houses, and Saint Paul's school building. The street in front of the Phœnix block is paved with Concord granite. There is much concrete used for street paving and sidewalks; the curbs are of granite from the native quarries.

CUMBERLAND, MARYLAND.

The only stones used for construction in Cumberland are Medina and Oriskany sandstones, of which there is an abundant supply in the immediate vicinity, and limestone quarried at Iron's mountain, on the old town road, about 3 miles from Cumberland. The chief uses to which stone has been put in the vicinity of Cumberland have been in the construction of canal walls and locks and dams. The Erett's Creek aqueduct, below the town, is also a good specimen of stone masonry, and is constructed of the limestone from Iron's mountain. The Medina or white sandstone is an admirable building stone. It is fine-grained, easily worked, and especially adapted to situations of exposure to the changes of the weather, as it neither scales nor crumbles. One of the finest churches (Presbyterian) is built entirely of this material, which is used in foundations, underpinnings, walls, sills, curbing, street-crossings, steps, and for capping walls which are built of other stone. The Oriskany or yellow sandstone ranks next as an available building stone for use here, and several quarries have been opened within the city limits. This is quite soft and is much more easily worked than the Medina stone, but does not stand exposure so well, and is not as durable. Of it also one of the principal churches, the Episcopal, is built. Where great weight is to be sustained, as in the foundations in the city hall, the Medina or white stone has been preferred; but for underpinnings, walls, window-caps, and for nearly every purpose, the Oriskany stone has been largely employed. Dressed, for stone fronts, it has been used to decided advantage in two of the handsomest residences; and in the Rose Hill cemetery monumental shafts and vaults have been built of it.

But little limestone has been used here as a building material. The stone of which the Chesapeake and Ohio canal locks, etc., are built was procured 3 miles from Cumberland, and is very durable. The iron sandstone, so called, is an iron ore, or rather a ferruginous sandstone, containing about 18 per cent. of metallic iron. This peculiar material has been made use of to a limited degree, notably in an extended wall on Washington street, capped with white sandstone. It is extremely hard, forms a structure of great durability, and is found in the vicinity.

DAVENPORT, IOWA.

Lumber is cheap, and excellent brick may be manufactured in unlimited quantities from the löess which caps the river bluffs. The stone found in the vicinity is either of a very uniform quality or of the fine, compact, non-magnesian character of the purer strata of the Hamilton formation in Iowa; which stone is hard, closely-jointed, and refractory under the hammer, and in part liable to suffer disintegration under atmospheric agencies, chiefly from the action of frost. Stone brought from other localities is a relatively costly material. There are no local circumstances unfavorable to the use of any good building stones, and the rock substratum beneath much of the city is peculiarly suitable for the foundations of heavy structures. There are no docks, wharves, fortifications, or breakwaters, and no stone sewers. There is an iron bridge across the Mississippi at this point, the piers at the Davenport end being of stone. Trinity church is built partly of limestone from the city quarries. The streets are largely macadamized with the local limestone, and a few of the sidewalks are paved with Anamosa and Joliet limestones.

DAYTON, OHIO.

There are small isolated areas of what is called the Dayton limestone, which is of Niagara age, exposed in the vicinity, and it is on this formation that the celebrated Dayton quarries are located. The court-house and bridges over the canal and the Miami river are built of stone from the Dayton quarries. Sandstone from Portsmouth and Berea is used to a considerable extent, chiefly for trimmings. The streets are largely macadamized with limestone from the Dayton quarries, and a few streets are paved with cobble-stones. Many of the sidewalks are paved with local stone.

DENVER, COLORADO.

The Windsor hotel and the Union depot are of rhyolite, the latter trimmed with Morrison sandstone. The Union Pacific freight depot and the Denver and Rio Grande depot are of rhyolite. The only other stone used for building purposes in Denver is sandstone from Canon City, Manitou, Fort Collins, and Trinidad. The quarries near this place lie at the foot of the mountains to both the north and the south of the city. The stones are white and red sandstone obtained from the lower horizons of the Cretaceous; some of the white sandstones are possibly from the Jura. A light pinkish-gray rhyolite which has broken through the Tertiary strata half-way between Denver and Colorado Springs is a favorite building stone in Denver; it seems to wear well, is easily worked, but will not stand fire. The streets are not paved; a few sidewalks are paved with sandstone flags from Fort Collins; curbs are of the Morrison sandstone. Bridge piers on Cherry creek and Platte are of rhyolite from Castle Rock.

DERBY, CONNECTICUT.

The material chiefly used in Derby for stone construction is the gneiss from Ansonia. Of the twelve stone buildings in the city eleven are of the Ansonia gneiss and one of rubble-stone from Birmingham. There is no other stone used here except a very small amount of North River blue-stone for sidewalk pavements and for curbstones, while the gneiss before mentioned is used to a limited extent for the same purposes. The bridge abutments across the canal and the Naugatuck river are built of the Ansonia gneiss. There are no paved streets. The Ansonia gneiss is a good material for all ordinary purposes of construction, and is the only building stone to be found in the vicinity.

DES MOINES, IOWA.

Most of the building stone heretofore employed is from Earlham, all of which, except a single ledge in the Bear Creek quarry, is regarded as inferior. It is reported by the city engineer that certain stones from the Earlham quarries are durable and strong, while others undistinguishable in appearance disintegrate rapidly. It is probable that the rock is not sufficiently seasoned before using. The quarrymen think that little if any seasoning is required. Wood is a cheaper building material than stone, as the nearest quarries are so far from Des Moines that freights add very materially to the cost. Rubble, which costs one cent per cubic foot in the Earlham quarries, costs 5 cents per cubic foot delivered in Des Moines. Excellent building stones exist in unlimited quantities in Winterset, in Madison county, near Tracy and Pella, in Marion, and at Givin and elsewhere in Mahaska county, at little greater distance from Des Moines than is Earlham. The new state capitol now in process of construction, with the superstructure nearly completed, is the only important public building in the city. The following is a statement of the building stones used in the state capitol, and the number of cubic feet of each kind:

	Cubic feet.
Granite from Grandy and Marion bowlders	6,650
Granite, Minnesota	3,034
Granite from Mountain, Missouri	1,616
Total	11,300
Sandstone from Carroll and Sainte Geneviève counties, Missouri	284,259
Limestone, dimension	172,924
Rubble and concrete	70,136
Total	527,319

The rubble comes from Bear Creek quarries, 2½ miles north of Earlham; the dimension stone to the ground-line comes from Winterset, Madison county; the limestone dimension, constituting the basement story, comes from Northbend, Johnson county; some limestone used in the interior piers of the basement comes from Anamosa, Jones county, and some used in the interior columns and pillars comes from Lemont, Illinois, the quantity being small. A considerable quantity of limestone from Rock Creek, Van Buren county, was used in building the foundation; but it was found to disintegrate so rapidly under the action of frost that it was afterward removed. It appears from reports of various quarrymen that small quantities of stone from localities not above mentioned have also been used in the construction of the state-house. There are no sewers except temporary drains. A system of sewerage is now in contemplation, and the paving of the streets is deferred until such sewers are completed. There are no wharves; but there are two iron bridges across the Des Moines river, the piers and abutments of which are of limestone, mainly from Earlham. Of the three railway bridges across the Des Moines river, that of the Chicago, Rock Island, and Pacific railroad has piers and abutments constructed mainly from Earlham limestone. The streets are not paved with stone; there is a little sidewalk pavement, of Joliet limestone, with curbs of Joliet, Pella, and Earlham stone.

DUBUQUE, IOWA.

The city is located upon an alluvial terrace and bottom, the materials of which are sufficiently firm to support buildings of any weight, provided care is used in the preparation of the foundations. Lumber is cheap and abundant; bricks are cheap and are the principal material for buildings; but limestone from the local quarries is used exclusively in the construction of sewers. There is a cross-street (Seventeenth street) located in the course of a ravine heading in the high bluffs to the westward, and in order to prevent destructive overflows it has been graded below the ordinary level, paved, and flanked with walls of masonry, so that during freshets the street itself serves as a drainage channel. The Galena limestone from the local quarries was employed exclusively in this work. An extensive artificial embankment for a levee, used for a wharf and utilized as a site for many important buildings, is protected by riprapping, in which the same material is used. The Episcopal church is built partly of limestone quarried near Farley station. The material for the abutments of the railroad bridge across the river was largely obtained from a tunnel in Galena limestone at the Illinois end of the bridge. The building used as a custom-house and post-office is constructed of limestone of the age of the Saint Louis formation quarried at Nauvoo, Illinois. Five per cent. of the street area is paved with the limestone from local quarries, and other streets are macadamized with the same material; except on the main street there is but little sidewalk pavement, and the material used is limestone from Anamosa and Farley, in Iowa, and Joliet, Illinois, and to a very limited extent the blue limestone of Trenton age from quarries 15 miles north of the city, on the Wisconsin side of the river.

EASTON, PENNSYLVANIA.

Easton is situated on moderately uneven ground, portions of the town being located on low ground on the banks of the Lehigh and the Delaware rivers, the junction of which is here, but the greater part is built on ground considerably elevated above the rivers. The surface everywhere offers firm and secure foundations. The limestone quarried in the vicinity is the material used for all ordinary purposes of construction. It is about the lowest limestone in the geological scale within the limits of Pennsylvania, being probably the bottom of the Siluro-Cambrian formation. The brownstone quarries of Triassic age located in New Jersey are readily accessible from here, and are considerably drawn on for building material by Easton. The principal stone buildings are Pardee hall, of Trenton sandstone, with Ohio sandstone trimmings; several churches are also of Trenton sandstone, and the front of the jail is of the same material. The Wyoming blue-stone from near Meshoppen is now being introduced for trimmings. The stone sidewalk pavement is not extensive, and the materials used for this purpose are Wyoming blue-stone, and North River and Lehigh slate. Curbstones are of native limestone.

ELIZABETH, NEW JERSEY.

In the business parts of the city, in the large buildings, brick is mostly used, although there are many of wood; but private residences are almost exclusively frame buildings. Brownstone is used in trimmings and in cellar walls and foundations, but not to so great an extent as brick. Saint John's Protestant Episcopal church is a fine example of brick trimmed with stone. Dark red sandstone was formerly used for grave-stones in the cemetery of this church, and these old stones are beginning to scale off. Several bridges over the river are built of sandstone, but these are small. Of streets opened and graded the total length is 79 miles; of paved streets, 26 miles; rectangular-block pavements, part granite and part trap-rock, 13 miles; the greater part of the trap-rock is from the Hudson County quarries. Of the three stone structures the most prominent is the Westminster Presbyterian church.

ELMIRA, NEW YORK.

The materials used for stone construction in Elmira are, for foundations and underpinnings, sandstone from the local quarries; for the better class of work, sandstone from the local quarries and limestones from Syracuse. The quarries of sandstone in the vicinity supply all the railroad work, except that in which heavy stone is needed, in which case the material comes from Unionville and Waterloo. The streets are not paved with stone, with the exception of two blocks, which are paved with Medina sandstone. But few of the sidewalks are paved with stone; the material used is blue-stone from Trumansburgh.

ERIE, PENNSYLVANIA.

Three stone structures in Erie are constructed of Medina and Amherst sandstone and Sandusky limestone, with one building of marble from Dorset, Vermont. The material for foundations and other rough purposes is a sandstone of the Upper Devonian age quarried in the immediate vicinity, and a sandstone of sub-Carboniferous age quarried at Corry, in Erie county. Sandstone quarried at Lebœuf, in the same county, is used to some extent for foundations and bridge abutments, flagging, caps, and sills. The streets are largely paved with stone, the

material most used for this purpose being the Medina sandstone; rubble is also used to a considerable extent. Sidewalks are but little paved with stone, and the material used is chiefly blue-stone from Euclid, Ohio; the Berea, Ohio, sandstone being also employed to some extent. The material commonly used for curbstones is the Medina sandstone. The stone from the quarries along the lake shore east of Erie, used for foundations, is a rather inferior material, but as it can be obtained at small expense, it is employed quite extensively for the underground portions of foundations; but some of it is not capable of withstanding the action of frost.

EVANSVILLE, INDIANA.

In the western part of the city the ground is unfavorable to building, as quicksand underlies the surface; but in the eastern and central parts this unfavorable condition does not exist. There is but one building entirely of stone, but ninety-nine buildings have stone fronts. The materials used in these buildings are the Bedford and Ellettsville limestones. Limestone of the sub-Carboniferous age, from the vicinity of Spencer, Owen county, was employed in the construction of the custom house. The foundations and underpinnings are of limestone quarried in the vicinity of Evansville. The streets are but little paved with stone, and the material is the limestone from the various points in Vanderburgh county, in which the city is situated. The sidewalks of the business streets are usually paved with the Bedford limestone, with crossings of limestone from North Vernon, Indiana. Curbs are of Portsmouth, Ohio, sandstone, as in the case of most of the other important towns on the Ohio river; the wharves here are constructed of cobble-stones on the banks of the river.

FALL RIVER, MASSACHUSETTS.

About 40 structures in Fall River, mostly mills, are of stone, the material used being granite from local quarries. Among the buildings of Fall River granite is the city hall. The new post-office and custom-house building is of granite in part from Westerly, Rhode Island. The mills before spoken of are, comparatively speaking, handsome structures, and the material of which they are built was quarried by the builder as it was needed in their construction. Some of the material in these structures is surface rock taken from the fields in the vicinity and from the outcrops of granite ledges. A portion of one of the streets is paved with granite blocks from the Fall River Granite Company's quarries in Freetown, and some streets are paved with cobble-stone from the drift in the vicinity. A few of the sidewalks in the older portions of the city are paved with the North River flags, and the curbstones are granite from Fall River quarries.

FITCHBURG, MASSACHUSETTS.

There are only two buildings in Fitchburg entirely of stone; the court-house and the Episcopal church are both built of granite from Fitzwilliam, New Hampshire. There are two stone fronts built of granite from the local quarries. The Fitchburg granite comes from Rollstone hill, about half a mile distant from the railroad station. Foundations and underpinnings are of Fitchburg and Fitzwilliam granite. There is but little stone street pavement, and the material used is the Fitchburg granite; sidewalks are not paved with stone, and curbs are of granite from local quarries.

FORT WAYNE, INDIANA.

There are but five stone buildings reported in the city. Limestone from White House, Ohio, is perhaps next in importance for foundations to that of the Wabash, Indiana. Limestone from the state is used to some extent for foundations of small structures. Stone is used to a considerable extent for paving sidewalks, though brick is used to a much greater extent. The Amherst, Ohio, sandstone was formerly used almost exclusively for the different purposes for which sandstone is commonly employed in this city—monument bases, caps, sills, and trimmings in general—but the Buena Vista sandstone is used almost exclusively now, because it is obtained here at a little lower price. The sandstone from Stony Point, Michigan, is considered by some builders to be equal in quality to the Amherst stone, but its brown color is objectionable to some. Foundations and underpinnings are of the Wabash limestone, and to a limited extent, some stone from Stony Point. The streets are macadamized with Wabash limestone, and a few of the sidewalks are paved with sandstone from Berea, Ohio, and limestone from Joliet, Illinois; the curbs are of the Joliet limestone; bridge abutments are built principally of sandstone from Stony Point, Michigan.

GALVESTON, TEXAS.

A few foundations in this city are built of stone brought in ships as ballast from various parts of the world, and all that has thus far been employed proves substantial and durable. The city is built on a sand-bank, and the usual manner of preparing the foundations of the largest buildings is simply to remove the top soil, which is only a few inches thick, and, provided there is no danger of the sand wasting from under, every inch deeper is

considered money thrown away. In sinking an artesian well recently silt was struck at 720 feet; all above this was sand, shell, and clay, or beds of silt in varying thicknesses. The United States government is using for the jetties the calcareous sandstone from a quarry 9 miles from Brenham, on the Gulf, Colorado, and Santa Fé railroad; also limestone from points on the East Texas railway. Both of the above stones make reliable masonry, and they are used on the railroad for bridge abutments and piers; they are rather porous. The ship ballast used so much for foundations and underpinnings comes chiefly from the northern United States, from Canada, and from Europe. There are but 20 square yards of stone street pavement in the city, and this is of cobble-stone brought as ship ballast. A few sidewalks are paved with sandstone, blue limestone, and granite from Connecticut, and from Germany and England.

GLOUCESTER, MASSACHUSETTS.

The six structures entirely of stone and the four stone fronts in this city are built of Gloucester granite. The only stone used for any purpose, with the exception of a few perches of lintel stone from New Brunswick, is granite from the quarries within the city limits. The streets are but little paved with stone, the material being the Gloucester granite; the sidewalks are not paved with stone, and there are some curbs of the granite from the local quarries.

HARRISBURG, PENNSYLVANIA.

Brown sandstone of the Triassic age is largely used in Harrisburg. Some of it comes from the Connecticut valley and some from Goldsboro', York county, but at present it is nearly all obtained from Hummelstown, Dauphin county, which is but a short distance east of Harrisburg. The climate here is rather severe on the brownstone, from whatever locality it comes. In buildings of this material it was noticed that blocks at the base, where more subject to sudden alternations of dampness and frost, are scaling off in thin flakes, while the stone higher in the wall remains unaffected. The stone-work about the base of the Pennsylvania State Capitol building is of brownstone from Goldsboro', York county, the superstructure being of brick; the brownstone is scaling off rapidly, due probably in a great measure to unskillful handling, as well as to the effects of damp and frosty atmosphere. Many of the stones are set up edgewise, instead of being laid as in the quarry. The Hummelstown brownstone is steadily increasing in use here. Front street, facing the Susquehanna river, seems to be the locality in this city most severe on building stones; the street is more exposed to rapid alternations of damp and cold weather than the other parts of the city. The material mostly used for the rougher building purposes, such as cellar walls and foundations, is the blue magnesian limestone quarried in the immediate vicinity, and most of the stone buildings are of this material. It is quite durable, the weather having apparently no effect on it, except to fade it to a light color; it is hard and brittle, and not readily susceptible of a fine dressing. Several private residences are built of blocks of this limestone of irregular shape firmly cemented together, and the effect is very pleasing. One of these, the house of Hon. Simon Cameron, was built by the founder of Harrisburg a century ago. In trimmings, curbing and steps, the Amherst, Ohio, sandstone is used in a few instances, but its use here is of recent date: the material as yet shows no sign of being affected by the elements. One building, the Dauphin County prison, is built principally of a gray, conglomeratic sandstone quarried several miles south of Harrisburg, near the Susquehanna river. The building was constructed in 1840, and the stone in the walls has been redressed several times since its construction; this is made necessary by the constant scaling off of the dressed surface in thin flakes. It was thought to be a most substantial material at first, but its vulnerable character is now so generally recognized that it is no longer quarried for building purposes. For underpinnings, steps, base courses, caps, and sills, Conewago granite, a dolerite quarried from the trap dikes which cut the Triassic formation at various places, is used to a considerable extent. The quarries which supply Harrisburg with this stone are principally those at Collins station, Lancaster county, and York Haven, York county. The material is practically indestructible, but its somber, dead color restricts it to uses in which fine effect is not desired. The abutments of bridges crossing the Susquehanna river here are constructed of the magnesian limestone quarried at Bridgeport, opposite Harrisburg; the abutments are repaired in places with patches of Hummelstown brownstone. The Dauphin County soldiers' monument is built of the trap rock called Conewago granite; the superstructure is of Maryland marble, and the figure surmounting the column is of Carrara (Italian) marble. For curbs, base courses, caps, sills, etc., Conewago granite and Montgomery county and Maryland marbles are all used to a considerable extent. One new house is being trimmed with the Wyoming blue-stone, a handsome, fine-grained and uniform, rather light blue sandstone from Meshoppen, Wyoming county. The new post-office building, in course of construction, has a foundation of Conewago granite from Collins station, Lancaster county; the exposed part of the foundation is of Old Dominion granite, a biotite granite quarried near Richmond, Virginia, and a superstructure of granite from Bluehill, Maine; the latter two materials resemble each other very much. The streets are but little paved with stone, and that most used for this purpose is cobble-stone from the Susquehanna river. There is but little sidewalk paving; the material used is the North River blue-stone, well known through the eastern states as a paving material. For roofing, Peach Bottom slate from the slate district in York county and the adjoining district of Maryland, is most extensively used, and slate from Lehigh and Northampton counties is also used for the same purpose.

HARTFORD, CONNECTICUT.

As the celebrated quarries of brownstone in the Connecticut valley are of easy access to Hartford, this is the source from which the city draws most of its material for stone construction. A few buildings are constructed of marble from East Canaan, and granite from Westerly, Rhode Island, is employed to a considerable extent; and in one building granite from Glastonbury is used. There are three or four stone bridges across Park river, and a retaining-wall about 500 feet in length and 20 feet high along the same river, all of Portland brown sandstone. The state capitol is by far the most important of the marble structures, the others being simply the fronts of three blocks of buildings. Many blocks in the walls of the state house are of crumbly material: flakes can be taken from them and rubbed to powder between the fingers. Limestone from Glens Falls, New York, is used in some of the inside stone-work of the state-house. In the United States custom-house and post-office granite from Saint George, Maine, was used. Light gray granite from Hallowell, Maine, was used in the construction of the monument to General Stedman. The streets are nearly all telfordized or macadamized with trap from quarries immediately southwest of Hartford. Sidewalks are largely paved with the North River blue-stone, and Bolton flagging-stone is used to some extent. The curbstones are of gneiss from quarries in Glastonbury, and of North River blue-stone.

HAVERHILL, MASSACHUSETTS.

The 15 buildings enumerated in Haverhill as having stone fronts are merely faced with Maine or New Hampshire granite for the first one or two lower stories. The one building constructed entirely of stone is a fine, large summer residence of an inferior quality of granite taken from the hill upon which the house stands. Foundations and underpinnings are of Cape Ann and Maine granite. There is a little stone street pavement of Cape Ann granite; the sidewalks are not paved with stone; curbs are of Cape Ann granite. The piers of the bridge across the Merrimack river are of Maine granite.

INDIANAPOLIS, INDIANA.

The stone most used in Indianapolis for the ordinary purposes of construction is the limestone from Indiana quarries. The sub-Carboniferous sandstone from near Portsmouth, Ohio, has been employed to a considerable extent. The Niagara limestones from Decatur and the neighboring counties may be used as ashlar in the construction of the walls without much dressing, causing a very considerable saving in mason work.

The Putnamville siliceous limestone lies in even courses from 4 inches to 2 feet in thickness. It is a silicate of lime, and resists the action of the elements admirably. Specimens exposed to extreme variations of temperature for forty six years still retain the chisel marks as fresh as when first dressed; and a door-step of a college resisted the daily foot-wear for fifty years, with wear of less than one-sixteenth of an inch.

The oolitic limestone when soiled is quickly made bright and clean by the inexpensive process of brushing with steel or wire brushes. True, smooth, highly-colored stone tiles of the best quality are made here of this material. The piers and abutments of bridges and cell walls of jails are largely constructed of Niagara limestone from Decatur county, and Indiana oolitic limestone is used for the same purpose. The approaches to the tunnel under the railroads on Illinois street are built of Niagara limestone from Decatur county. Siliceous limestone of the sub-Carboniferous period, quarried at Putnamville, was used for foundations, curbs, and paving flags some years ago, and has shown valuable qualities for resisting the action of weather, time, and fire. Its use was discontinued by reason of a more easy access to other quarries. The new state-house, when completed, will contain 410,000 cubic feet of Niagara limestone and 520,000 cubic feet of oolitic limestone. The foundations and underpinnings are of the Niagara and Devonian limestones quarried in Decatur and Jennings counties, and the sub-Carboniferous from Owen county is used to a limited extent. Granite from Hurricane island, Maine, was employed to some extent in the stone-work of the capitol, and limestone from North Vernon, Jennings county, was used in the construction of the Indianapolis arsenal. In such streets as are paved the cobble-stones are used exclusively. Sidewalks are largely paved on the business streets with Niagara limestone from Decatur county, and artificial cement is used to a limited extent. Curbstones are of Decatur County limestone.

ITHACA, NEW YORK.

About the only material used for stone construction in Ithaca is the sandstone quarried in the immediate vicinity. Cornell University buildings are of stone from quarries near them: some in fact are within the grounds of the university. The trimmings are of Berea, Ohio, sandstone, Lockport limestone, and Medina sandstone, from Albion. The streets are not paved with stone; the sidewalks are largely paved with blue-stone from quarries near the city, with curbstones of the same material. The total amount of stone construction in Ithaca is small, only 15 buildings being reported as constructed of this material.

KEOKUK, IOWA.

The stone buildings thus far erected are among the largest of the city. The sandstone of Sonora, Illinois appears to be an excellent and durable building stone. Quarries of similar material are found on the Iowa side of the Mississippi, near the mouth of the Des Moines river, and also 5 or 6 miles above Keokuk, which have been operated only a short time. The abutments and piers of the railway bridge across the Mississippi are of arenaceous limestone from Sonora, Illinois. The stone used in the construction of the Des Moines Rapids canal is mainly from the same locality, though in part from temporary quarries of similar stone near Nashville, Iowa. The stones for foundations and underpinnings and the ruder purposes generally is limestone of sub-Carboniferous age quarried within the city limits: this material was used in the construction of the opera house (foundations) and the Keokuk Elevator Company's elevator. The streets are not paved, but some of them are macadamized with the local stone. A few of the sidewalks are paved with limestone from within the city limits.

KINGSTON, NEW YORK.

Of the stone buildings 34 are old dwelling-houses. These are generally 1½ stories high, and are built of surface rock, mostly limestone and graywacke; some few are stuccoed. As good examples of durability we may mention the old Senate house, built by Wessells & Tenbrook in 1676. The Hasbrouck and Bruyn houses are also very old. Hard surface stone used in these buildings have suffered scarcely any change such as weathering might induce. Of the more prominent buildings the Ulster County court-house was erected in 1818, and still looks bright and clean; the First Reformed church is the largest and most costly stone building in the city; it is built of a dark slate-colored grit or graywacke found in the neighborhood. The stone is thinly-bedded, but looks well. The Second Reformed Church building is of limestone; the material is much disfigured by the brown and dirt-colored stains due to the weathering of the clay seams of the mass. These stains reach in all directions through the stone. The superiority of the surface stones which appear in the old houses is evident at a glance. This limestone came from quarries near the town. Ohio sandstone has been employed in the trimmings of the new city hall; otherwise it has been scarcely used. The lower portions of the city are of brick. The aggregate length of paved streets, according to ex-Mayor James T. Lindsley, is less than one mile, and is confined to three streets. In front of two blocks the street is paved with granite blocks. For the most part foundations and underpinnings are from the blue-stone flag quarries at Kingston and Hurley, Ulster county. Some of this work, however, is of limestone, blue rock, and slate quarried within the city limits. The sidewalks are largely paved with stone, there being about 60 miles of flagging of blue-stone from quarries at Kingston and Hurley. Curbstones are of the same material. The large amount of stone sidewalk paving is due to the close proximity of the city to the most celebrated flag-quarry region in the country.

LA FAYETTE, INDIANA.

Stone used for building purposes in this city is almost exclusively limestone from the quarries of Decatur, Lawrence, and Monroe counties. It is used quite extensively for trimmings; its light color gives a fine architectural effect when used in connection with brick. The streets are not paved with stone, but the gutters are laid with bowlders gathered in the vicinity. A few of the sidewalks are paved with limestone from Greensburg, with curbs of the same material.

LANCASTER, PENNSYLVANIA.

A large percentage of the buildings in Lancaster have considerable stone in their composition, in the way of base courses, caps, sills, etc. Stone is used to bring the base of the houses to a level on the uneven ground, and brownstone from Hummelstown, from Ephrata, in Lancaster county, and from other points is used for the purposes mentioned. Connecticut brownstone is employed in a few instances. The Conewago granite, from the Kellar quarry near Collins station, is frequently used for base courses. It is apparently invulnerable to the attacks of the elements

Amherst, Ohio, stone is used to some extent for base courses and trimmings.

Blue-stone from Meshoppen and other points in Wyoming county is being introduced for trimmings and is very highly esteemed. Montgomery County marble is well adapted to the construction of fronts, base courses, caps, and sills, for which purposes it is much employed in Lancaster.

In the cemeteries the New England marble is employed to a considerable extent, also Montgomery County marble: granite from the New England states and from Maryland, and some Scotch granite; Hummelstown and Connecticut brownstone to a small extent; and for lot inclosures, Conewago granite. Some houses in the city are trimmed with white marble from Sutherland Falls, Vermont. For foundations and underpinnings the material ordinarily employed is magnesian limestone, which is quarried in the vicinity, and the old houses in the city are built of the same material. The streets are largely paved with stone, the greater part, however, being simply macadamized with the limestone quarried in the vicinity. The public square and portions of other streets are

paved with granite blocks from cape Ann, Massachusetts. The sidewalks are largely paved with stone, the material chiefly used being Wyoming blue-stone from near Meshoppen, Pennsylvania. The North River blue-stone is also used to some extent for sidewalk paving. Lehigh County slate is used for sidewalk paving. Bridge abutments, culverts, and embankment walls are constructed of Silurо Cambrian limestone quarried in the vicinity. The soldiers' monument is built of white marble, the base being of New England granite. The Peach Bottom slate is highly esteemed for roofing, and the Lehigh County slate is also extensively used for the same purpose.

LAWRENCE, MASSACHUSETTS.

The only important stone buildings in Lawrence are two large Catholic churches, one Congregational church, and a large prison. Stone has thus far been used to a very limited extent as material for construction in Lawrence, except as underpinning. The factories and tenement houses are almost all of brick, while the suburban residences are of wood. The same may be said of Lowell and Haverhill. The material for foundations and underpinnings is granite from New Hampshire and from cape Ann and Westford, Massachusetts. The streets are largely paved with Cape Ann and Westford granite. A few of the sidewalks are paved with Cape Ann granite, and curbs are of the same material.

LEAVENWORTH, KANSAS.

The limestone chiefly used in this city is from a 14-foot bed occurring about 20 feet above the ordinary water-mark in the river; it is of Upper Carboniferous age, and corresponds to No. 112 of section U. C. M. (See p. 94 of Part II, *Missouri Geological Report of* 1872.) Four feet above is another limestone (No. 115, Missouri section) which has been extensively used at Leavenworth city for sidewalks and foundations, but it often shows many sand tracts. Other rocks used largely at this city are from Junction City and Cottonwood Falls, Kansas. Cottonwood limestone was used in the construction of the court-house and the Missouri Valley Life Insurance building. The columns of the custom-house are of red granite from Red Beach, Maine. The riverside quarries at Leavenworth have been abandoned on account of the cost of stripping; at the present quarries there are from 4 to 8 feet stripping of earth and shales. Foundations are all rubble-stone from local quarries and from Fort Scott. The streets are largely macadamized with the limestone from local quarries; the sidewalks, however, are chiefly paved with brick, and to a limited extent with limestone from near Fort Scott. The only building constructed entirely of stone in the city is built of the local limestones.

LOCKPORT, NEW YORK.

Within the limits of this city there are extensive quarries of both sandstone and limestone, and they furnish all the material used for stone construction. The sandstone quarries are located on a ledge of Medina sandstone age, and by far the larger number of stone buildings are constructed of this material. It is used to some extent also for sidewalk paving and street paving blocks. The greater part of the material for stone construction in Buffalo is also brought from these quarries. The limestone quarries are located on a ledge of Niagara age and on the same horizon as that over which the cataract of Niagara flows.

The foundations and underpinnings are usually constructed of limestone from the local quarries, but the Medina sandstone is also used for these purposes to a limited extent. The streets are but little paved with stone, there being only a quarter of a mile of the Medina block pavement. There is but little stone sidewalk pavement, the material used for sidewalks being planks; in such sidewalks as are paved with stone the Medina sandstone is the material used. Five double locks on the Erie canal are of limestone from local quarries and from the canal excavation.

LOGANSPORT, INDIANA.

The limestone that has been used so extensively in this city for entire buildings is taken from the quarries 3 miles below the city, on the Wabash river. The color of the stone is gray and quite uniform, and some of the finest structures in the city have been built of it. Oolitic limestone from southern Indiana is used extensively for trimmings; that from Stinesville is perhaps used most extensively at present for this purpose. The Amherst and Berea sandstones of northern Ohio were used to a limited extent for the same purposes. The Buena Vista stone of sub Carboniferous age, quarried in southern Ohio, has been used for ashlar. The limestone quarried in the vicinity of the city furnishes material for foundations and underpinnings. The sidewalks are largely paved with limestone from southern Indiana and sandstone from Berea, Ohio; the curbs are of native limestone. The material used for bridge abutments and piers is sandstone from Williamsport and Attica, and limestone from Logansport, and the oolitic limestone from the southern part of the state.

LOUISVILLE, KENTUCKY.

The rock exposed in the immediate vicinity of Louisville is the sub-Carboniferous limestone, which is of the same age as the Indiana oolitic limestones; hence the city has a good local supply of building stone which answers well for all ordinary purposes of construction, and extensive use is made of this supply. For the finer purposes of construction the Indiana oolitic limestones are extensively used, and as the city is situated on the Ohio river it has ready access to the Buena Vista and other sandstone quarries near Portsmouth, Ohio, and much of this stone is used. The Bowling Green, Kentucky, limestone has also been very extensively employed. This limestone, like that of the local quarries, is of sub-Carboniferous age. The Louisville limestone, however, although taking good rank as far as durability is concerned, is hard and sometimes flinty, and is much more expensive to dress than the sub-Carboniferous limestones usually are where exposed in other places, and this fact confines its use to the ruder purposes. The streets of Louisville are largely paved with limestone from the local quarries, and a few of the sidewalks are paved with Bowling Green limestone, with curbs of the same material. The abutments of the railroad bridge over the Ohio were built of Utica, Indiana, stone. The wharf is constructed of cobble-stones; the locks and walls of the Louisville canal are built of the local limestone; it was also used in the construction of the custom-house and the city work-house. Limestone of sub-Carboniferous age, quarried near West Salem, Washington county, Indiana, was used in the construction of the Galt house and the city hall. Sandstone from the vicinity of Cannelton, Perry county, Indiana, was used in the construction of the water-works and locks.

LOWELL, MASSACHUSETTS.

There is quite a number of small factories, barns, and dwelling-houses in Lowell constructed of the blue mortar-stone taken from quarries in the immediate vicinity of the city. This material is considered more durable than the very micaceous granite; the disadvantage in using it for building purposes lies in the great difficulty of quarrying blocks of given dimensions. The Concord granite is preferred, owing to the small amount of iron in its composition. There is a very micaceous gneiss quarried in the immediate vicinity somewhat used for building purposes, but it is liable to rust on account of the quantity of iron in its composition, and it also has a tendency to crumble when subjected to the action of intense heat.

The following are the different building stones most used in the better class of stone construction in this city: Granite from Concord, New Hampshire; mortar-stone, quarried in the immediate vicinity; marble from Rutland, Vermont; granite from Westford, Massachusetts; granite quarried in the vicinity of the city; foundations and underpinnings are of granite from Concord, New Hampshire, Westford granite, and the various stones quarried in the vicinity of Lowell. A very large bridge is being constructed across the Lowell railroad of stone quarried in Westford, Massachusetts; the Episcopal church and Saint Patrick's church in Lowell are built of stone taken from Livingston quarry, within the city limits. The streets are largely paved with Westford and Concord granites. There is some stone sidewalk paving of Westford granite, with curbstones of the same material.

MANCHESTER, NEW HAMPSHIRE.

A very few stone buildings in Manchester are constructed of granite quarried in the immediate vicinity. The materials usually employed in construction here are brick and wood. In the construction of the Amoskeag dam 50,000 cubic yards of granite were used. The walls of a canal a mile in length and the piers of six bridges across the Merrimack river are built of granite from Bedford. These quarries are not now operated. The soldiers' monument was built of Concord granite. Foundations and underpinnings are of granite and gneiss quarried in the vicinity, from the lake gneiss formation, and the granite occurring in masses in the gneiss. There is a mile of street pavement of Hookset granite in blocks a foot square. There is very little stone sidewalk pavement of gneiss from the immediate vicinity. The sidewalk in front of the Merchants' exchange is paved with Potsdam sandstone. The curbs are of native granite and gneiss.

MIDDLETOWN, CONNECTICUT.

On account of the close proximity of the Portland quarries, which are on the opposite side of the river from Middletown, almost all the stone used in this city is obtained from them. There are very few stone buildings, however, by far the largest use of the stone being for foundations and underpinnings. The sidewalks for the most part are from 3 to 4 feet apart, and they as well as the curbstones are of a kind of gneiss from the Haddam and Maromas quarries; this material splits with rather a rough surface. In the principal business streets large flags of North River blue-stone are considerably used, and in many spots slabs of sandstone occur, which, however, do not stand well under foot-wear. In buildings the dressed sandstone scales off badly when set on edge; when laid as in the natural bed this defect is not apparent. A large railroad bridge across the Connecticut river, at Middletown, has its piers and abutments built of a granitic rock taken from the quarry, worked only for this purpose, a short distance up the river on the east side. The streets are not paved.

MEMPHIS, TENNESSEE.

There are but two buildings in Memphis constructed entirely of stone, the custom house and the post-office. The first is built of marble from Knoxville, Tennessee; the second, of granite from near Iron Mountain, Iron county, Missouri. Eight buildings are enumerated as having stone fronts, one of which is built of sandstone from Alabama, six of limestone from Alabama and Kentucky, and one of freestone from near Portsmouth, Ohio. Foundations and underpinnings are chiefly of brick, but there are some of limestone from Alabama and Kentucky. Limestone is used in wharf paving and breakwater of riprap walls, of which there is now paved an area of 2,700 by 250 feet—equal to about 75,000 square yards. The arched culvert bridges and abutments are constructed chiefly of brick, and one arch culvert is built of limestone from Alabama.

The sewer system, built in 1880–'81, is constructed for the most part of vitrified clay pipe from 6 to 15 inches in diameter, the main outlet being of cast iron and brick 20 inches in diameter. Granite and sandstone quarried in the vicinity of Little Rock, Arkansas, are used for building purposes. Sandstone and limestone from Arkansas and Missouri, and limestone from Illinois, Kentucky, Tennessee, and Alabama are all employed in construction here. Most of the quarries are accessible by water and by railroad, and their distance from Memphis ranges from 200 to 250 miles. The buildings within the fire limits are chiefly of brick, with some iron. The site of this city furnishes good foundations for buildings of every description. About 15 miles of streets and alleys are paved with stone; the material chiefly used for this purpose is limestone from Illinois, Kentucky, Alabama, and Tennessee, and granite and sandstone from the vicinity of Little Rock, Arkansas. Sidewalks are but little paved with stone, and the material chiefly used is limestone and sandstone from Alabama, with curbs of the same material.

MINNEAPOLIS, MINNESOTA.

The following list includes the Minneapolis buildings in which stone enters as an important constituent:

Brick buildings with limestone trimmings from the Trenton formation	179
With Berea, Ohio, sandstone trimmings	60
With Frontenac dolomite trimmings	13
With Joliet or Lemont, Illinois, limestone trimmings	3
With Fond du Lac limestone trimmings	48
With Kasota stone trimmings	11
With Minnesota granite	6
Buildings of stone or brick partly trimmed with granite	21
Buildings of brick with Vermont marble trimmings	1

There are perhaps 20 other brick buildings which have artificial-stone trimmings and 20 which are trimmed with brick of another color, or are painted so as to simulate trimmings of stone, of which no account has been made. This enumeration includes all stone structures; many of them are very large, such as the Washburn A, B, and C flouring mills, the Pillsbury A flouring mill, the university of Minnesota, and McAllister college. The list also embraces the Universalist church, the Irish and French Catholic churches, and the Plymouth Congregational church. The Trenton limestone supplied by the quarries of Minneapolis, formerly much used, is being abandoned as material for first-class structures, and in its place are put stones from towns in Minnesota, as well as stone from other states. The argillaceous character of the Trenton strata, and the thin but often lenticular banding of the sedimentary structure, cause the slabs and blocks of this limestone to disintegrate in sheets parallel with the bedding, and finally to wholly decay; when it can be kept from exposure to the weather it answers for walls better; hence it is still employed in foundations and in basements that rise a few feet above the ground. It is necessary even in such cases that it be well bedded in mortar and protected by a good water-table.

The use of stone as a material of construction at Minneapolis has been greatly influenced by an abundant supply of two other articles, as follows, viz: Cream-colored brick and pine lumber. It is becoming very fashionable to use red pressed brick from Saint Louis or Philadelphia or Baltimore for the fronts of first-class structures, trimming them with sandstone from Ohio, or limestone from Stone City, Iowa, or Joliet, Illinois. The piers of the suspension bridge over the Mississippi river and its anchorages are of the Trenton limestone, from Minneapolis, trimmed with Minnesota granite. The piers of the two other highway bridges and of the railroad bridge across the Mississippi are of the same material. The arched bridge across the east channel of the Mississippi is of the same, but has Red Wing rock in the angles. In several residences and business blocks artificial stone is used for window-caps or other trimmings, but with Trenton limestone sills, basements, and water-tables. Lemont, Illinois, limestone is seen in a few buildings which have other stones for trimmings. Steps and water-tables of Kasota stone are frequently put in buildings that have other stones for trimmings. In the Westminster Presbyterian church brown sandstone from Fond du Lac, Saint Louis county, Minnesota, is used.

The streets are but little paved, and the material used is a water-worn cobble-stone from the drift. Sidewalks are but very little paved with stone, owing to the abundance of pine lumber and its cheapness. In such sidewalks as are paved with stone, Niagara limestone, from Joliet, Illinois, Trenton limestone, from Minneapolis, and calciferous sand rock, from Kasota, Minnesota, are used. The curbstones are of Minneapolis Trenton limestone.

MOBILE, ALABAMA.

The only stone building in Mobile—the custom-house—is built of Quincy, Massachusetts, granite. The streets in the business portion of the city are partially paved and macadamized with stone ballast from vessels and the Alabama sandstone. The sidewalks are paved with Alabama sandstone and brick; sandstone from Colbert county, Alabama, is used to a limited extent for this purpose; also the North River blue-stone and stone brought from Yorkshire, England.

NASHVILLE, TENNESSEE.

The stone chiefly used for fronts in the city of Nashville is oolitic limestone from Bowling Green, Kentucky. It is a good material, but contains petroleum which is drawn to the surface by the heat of the sun, and dust settling on it turns it a dark color. It is not uniform in color, but has yellow streaks. The United States custom-house is built of this material. The limestones of the Nashville formation are found in three principal layers; the quality and appearance vary in the same layer. The quarry from which the stone for the capitol is built was abandoned for the reason that the material is very fossiliferous and the fossils (*orthoceras*) weather out. Some of the courses are liable to decomposition when exposed to the weather. The stone is very distinctly laminated; it is not a pure limestone, but has considerable silica in its composition. It is most durable when laid in walls, as in the natural bed. The use of stone for construction is very general in Nashville, nearly every building of any prominence having considerable stone in its composition, and all new stores have fronts either entirely or partially of stone.

Stone basement stories, with the upper portions of brick with stone trimmings, is a very common form of construction. The usual custom is to use the Nashville limestone below ground, and above ground a Nashville limestone, carefully selected, with Bowling Green superstructure and trimmings. There is a desire at present to substitute some other stone for the Bowling Green for the purposes of construction in which that material is now used. The capitol building is constructed entirely of stone; the pillars of the halls of the legislature and ornamental work, railings, etc., are of Hawkins and Knox County marbles. The stone used in the walls of the building is from the next to the lowest course of the Nashville formation.

The Normal College buildings are of local stone. The basements of the Vanderbilt and the Fisk universities are of Nashville stone; the copings and trimmings are of Bowling Green limestone, and their foundations are of selected Nashville limestone. The new United States custom-house is constructed entirely of Bowling Green limestone.

The ruling taste here at present seems to favor white building stone; two churches built many years ago are of Nashville limestone, and stuccoed to represent brownstone; another church is built of rough Nashville limestone of a bluish color. No granite is used in this city for building purposes. The stone used in cemeteries is chiefly Italian marble; however, the Knoxville marble is rapidly coming into use as a material for cemetery work, as it seems but little affected by exposure. There are some monuments of Quincy granite. There is a growing sentiment in favor of paving streets with stone, as the limestone now used in macadamizing powders rapidly, making an offensive dust in summer and mud in winter. Limestone of the Nashville, Cincinnati, or Hudson River formation is used for every character of work except fronts; it is frequently quarried in getting out foundations in such large quantities that it is given away. The walls of yards around the city are constructed of it; some with rough and some with dressed surfaces. Walls of buildings on the river and piers of the bridges are built of it; occasionally in handsome fences around large inclosures of fine residences, the corner and gate posts are constructed of Bowling Green limestone, and the wall around the capitol grounds is constructed of this material.

NEW ALBANY, INDIANA.

The percentage of stone construction in New Albany is small, the material chiefly used being brick and wood, with brick foundations under the frame buildings; but so far as stone has been used here it has shown itself to be substantial and durable, the materials being of superior quality. There are no local circumstances unfavorable to stone construction, and the stones used are limestone from Salem, Indiana, and, to a limited extent, sandstone from the vicinity. The West Salem limestone was employed in the construction of the court-house. For foundations and underpinnings and for other ordinary purposes limestone from the vicinity is employed. The streets are largely paved with cobble-stone and limestone found in the neighborhood. But few of the sidewalks are paved; the stone used is limestone from New Albany and Vernon; curbs are of the same material.

NEWARK, NEW JERSEY.

Nearly all of the prominent stone structures in Newark are built of the Newark sandstone, but the elegant United States custom-house and post-office building and the large and massive county court-house are of Little Falls, New Jersey, sandstone. Nearly all of these buildings are large and costly structures, and the beauty and durability of the stone used are exhibited to good advantage in many of them. Some of the larger edifices are especially deserving of

notice. The extensive use of stone in Newark is to be explained from the fact that there are five quarries of sandstone within the city limits; three of them are now worked, employing from 100 to 200 men, and their product is valued at $150,000 to $200,000 annually. There are many large and expensive private dwellings entirely of stone, and many with only stone fronts. Three bridges over Second river and 21 over the Morris canal are of Newark sandstone, and 24 miles of the Morris canal is walled with the same material. Six railroad bridges beside wagon bridges over the Passaic river have piers and abutments of Newark sandstone. One large trunk sewer is built of the same material, as are also many walls about lawns and cemeteries. The total length of improved and graded streets is 176.8 miles; of streets paved with cobble-stones, 28.76 miles; paved with granite and trap blocks, 4.89 miles; Telford or macadamized streets, 12.21 miles; total of stone pavement, 45.86 miles. The total length of streets graded and improved but not paved is 130.94 miles. The narrow streets have sidewalks 4 feet in width; other streets or sidewalks 5 and 6 feet in width. The material used in paving these sidewalks is the North River blue-stone. No brick is allowed to be used for this purpose.

NEW BEDFORD, MASSACHUSETTS.

Of the 27 buildings in New Bedford constructed entirely of stone, 19 are of granite quarried in the vicinity, 2 of Rockport granite, and 1 of Quincy granite. At the entrance to New Bedford harbor is a large fort, while a smaller one guards the Fairhaven side opposite. They are both constructed of Cape Ann granite. Foundations and underpinnings are of granite from the vicinity of the city and from Rockport. The streets are largely paved with cobble-stone from the vicinity: North River flagging stone is exclusively used in the sidewalks; curbs are of granite from Rockport, in the vicinity.

NEW BRUNSWICK, NEW JERSEY.

The comparative cheapness of brick has interfered with the use of stone both for building purposes and for sidewalks. The red sandstone quarried in the city was formerly used to a limited extent in cellar walls and foundations, but the quarries are now discontinued. This stone has not proved to be durable, crumbling slowly when exposed to severe frost. It is adapted to use in inside filling of walls only, and the greater durability and cheapness of brick have enabled the builders to dispense with it entirely. North River blue-stone has a large use in building for steps, sills, caps, and other trimmings, especially in factories and storehouses. The college buildings afford examples of good and poor stones and of materials improperly laid: the old college building rear wall contains some soft argillaceous sandstone, which tends to split, although laid as in its bed in the quarry. In the west wall there are many stones which show clay-holes. The Geological Hall building has a few examples of stone from Connecticut quarries, which are laid with the lines of bedding in a vertical position, and they are beginning to chip or scale off, although the building has been constructed only ten years. The superiority of the Newark stone is apparent in comparing the general effect, and in the closer examination of the single blocks as they occur in these two structures—the Geological hall and the Kirkpatrick chapel. The Newark stone does not show the lines of bedding so plainly; it is more homogeneous in its composition, and its materials are not so much arranged on lines or in parallel planes as they are in the Connecticut stone which is ordinarily put on the market here. The durability of the Newark stone is displayed in the old college building, erected in 1809; the corners and edges are still sharp and well defined. The following are some of the principal structures of stone, with the materials from which they are constructed: Rutgers college (main building): Newark sandstone; Geological hall: Connecticut sandstone; Kirkpatrick chapel: New Jersey sandstone; First Reformed (Dutch) church: gneiss from New York; the Protestant Episcopal church and Saint Peter's Roman Catholic church: New Jersey sandstone; residence of John Carpenter, residence of Sisters of Charity, and Bartel's private residence: Connecticut sandstone; piers of the wagon bridge over the Raritan river at Albany street: Connecticut brownstone: Pennsylvania Railroad company's bridge (8 piers and abutments): from Stanton, Hunterdon county, New Jersey, and gneiss from Conshohocken, Pennsylvania: the locks of the Delaware and Raritan canal: Trenton freestone, Greensburg quarries. These locks are 200 feet long, or 250 feet including the wing walls; one is a double lock.

The following is a statement of the amount and kind of stone street pavement in New Brunswick:

	Miles.
Granite block, Westerly, Rhode Island, granite	1/10
Cobblestone	2 7/10
Telford macadamized road of trap-rock	1 1/10
Total stone street pavement	4 1/10
Nicholson wood pavement	1
The sidewalk of North River blue-stone laid by a street commission	8

Curbstones, mainly of North River blue-stone.

NEWBURGH, NEW YORK.

The nearest available source of building stone for Newburgh is the limestone quarries within 2 miles of the city. The material obtained there is used for foundations, underpinnings, and other work of that class; Connecticut brownstone and Haverstraw stone are also used for foundations. Of the stone buildings in the city the oldest is a story-and-a-half dwelling-house constructed of surface stones from the vicinity, and occupied by Washington as headquarters during the encampment at Newburgh. Saint George's Protestant Episcopal church is an old building of blue limestone obtained west of the city. Saint Patrick's Roman Catholic church is a new and large structure of blue limestone, a stone which is much disfigured by what seem to be argillaceous seams traversing irregularly the calcareous matrix. The darker shades of color in these clay seams give the whole a rather dingy appearance. The stone was obtained in part from the quarries west of the city and in part from Kingston, Ulster county; the latter stone has suffered more by exposure. It resembles in this respect the stone in the Second Reformed church in Kingston, and both show how much care is needed in the selection of limestone for fine work in prominent buildings. The First Presbyterian church, a very large, costly, and ornate edifice, constructed of graywacke and flagging stone quarried near Kingston, is trimmed with Ohio sandstone; the stone has retained its dark color, and does not show any signs of disintegration by weathering. The other buildings are small and private excepting the stuccoed Reformed Church edifice. Formerly brownstone from Haverstraw and Nyack was much used for door-steps and window-sills, but of late Connecticut brownstone and Ohio sandstone have been used almost exclusively, excepting the blue limestone from the neighboring quarries, which is used for rough work and cellar walls. Brick here takes the place of stone to a very great extent in both foundations and superstructures. The sidewalks are all laid with blue flagging stone; in the older streets they are from 10 to 12 feet wide, and the stones are of irregular size and generally small. The more recently laid walks are 6 feet wide and are a single line of stone. The cost of paving some of the fine foot-sidewalks has been $1 per linear foot. The length of sidewalks is unknown, but amounts to many miles. The cobble-stone pavements measure 10,000 feet; the average width may be 40 feet. In the front of a single block in Water street the pavement is Belgian block. The sidewalks are all paved with blue-stone from Ulster county, with curbstones of the same.

NEWBURYPORT, MASSACHUSETTS.

There are but two buildings in Newburyport constructed entirely of stone, and the material used is Cape Ann granite. Foundations and underpinnings are usually of the same material, but Maine granite is used for the same purpose to a limited extent. With the exception of a very few public buildings, stone is used only in the underpinnings and foundations. It is observed that the Cape Ann granite, the stone chiefly used here, is of a light color when quarried and grows dark with exposure, but does not decay. The Peabody granite becomes of a yellowish-brown color after long exposure to the weather. A ledge has been recently opened about 2 miles above Newburyport, on the Merrimack, for the purpose of extracting stone for the construction of a jetty across the sand-bar at the mouth of the river. The material quarried is called by the workmen common stone or trap. Sandstone from Springfield has been used to a very limited extent for trimmings. The little stone street pavement in this city is of Maine granite; the sidewalks are not paved at all, and the curbs are of Maine and Cape Ann granites.

NEW HAVEN, CONNECTICUT.

In New Haven, as in most of the other cities of Connecticut, the brown sandstone from the Connecticut valley furnishes the chief part of the material for stone construction. The other materials used are granite from Long Island shore, gneiss from Ansonia, trap from the East and West rocks, and sandstone from East Haven and Ohio. The breakwater in New Haven harbor has been built partly of coarse granite from the Branford quarries; considerable of East Haven sandstone has been used in bridge approaches, abutments, and piers; some 2 or $2\frac{1}{2}$ miles in length of the side walls of the old canal, in which the railroads cross the city, are built entirely of East Haven sandstone and trap, about equal quantities of each being used, and requiring between 8,000 and 10,000 cubic yards of stone. Some of the Ohio sandstone used in New Haven, notably in one building, contains iron pyrites, which oxidizes on exposure to the weather, giving the stone a soiled appearance. The only defect noticeable in the Portland sandstone is that it scales off if laid otherwise than as in the quarry bed. The basement story of the old state-house is of limestone, which has crumbled very badly, and the material has not been used in any other structures. Brown sandstone from Newark, Essex county, New Jersey, was employed to some extent in some of the Yale College buildings. For foundations and underpinnings trap and East Haven sandstone are the materials used. Most of the streets are telfordized with trap from the East and West rocks. The sidewalks are but little paved with stone; the material used is North River blue-stone, with, in a few instances, mica-schist from Bolton, Connecticut. The curbstones are chiefly North River blue-stone, but granite has been used to a limited extent for the same purpose.

NEW LONDON, CONNECTICUT.

New London is built on granite rocks. Stone for cellars, foundations, and underpinnings is quarried almost anywhere within the city limits. The whole of the walls of the large Catholic church, and of another large granite church building, are built of stone quarried on the sites of buildings, the stone for trimmings coming from one of the quarries at Groton. The surface stone in New London, and also in neighboring quarries, is striped in appearance, not uniform, some pieces being more variegated than others. The color varies also considerably, but is always the same shade of gray.

Only 1 per cent. of the buildings is of stone, which is due simply to the question of first cost. Forts Trumbull and Griswold are built of granite from Groton or Millstone point.

The streets are but little paved with stone, and the material used for this purpose is the rectangular blocks of Groton granite. The sidewalks of the principal streets are paved with North River blue-stone and some Groton granite. The curbstones are Groton granite.

NEW ORLEANS, LOUISIANA.

The percentage of stone construction in New Orleans is very small. A large proportion of the houses are built of wood. The streets were all paved before the late war. There is one building, situated in the southern part of the city, entirely of rough-hewn stone from Sainte Genevieve. The custom-house is nearly all built of Quincy granite. Another building, on the corner of Royal and Canal streets, is built mostly of granite. A monument to General Robert E. Lee is now in course of construction; the base is of Georgia granite; the foundation on piles, and transverse timbers in concrete; the shaft is of Knoxville, Tennessee, gray marble; and this latter material is very highly esteemed here. The few stone fronts are of Westchester, New York, snowflake marble and Sainte Genevieve limestone; a good deal of the latter material was formerly used. The chief material now used for fronts is iron; the amount of stone used for purposes of construction in New Orleans since the war is very inconsiderable. The Westchester limestone was considerably employed before the war, and also the Sainte Genevieve limestone, for tombs and fronts; at present a great deal of brick is used and stuccoed. The use of artificial stone in buildings and pavements is increasing. The stone used for ornamental purposes is usually Italian marble, with some Vermont marble. Some Quincy granite was formerly brought to the city and used for curbstones, flagging, and purposes of that nature; as it was usually brought as ballast in ships, the expense attending its use was inconsiderable. The water is so near the surface in New Orleans that it is impossible to have stone foundations; the customary way is to lay thick planks transversely and to place the brick immediately on them; they are sometimes creosoted, but usually last well below water. This system of foundations is considered better and less expensive than driving piles. The sewers consist of stone faced gutters, through which the water passes every night from the river to the lake; 221,760 feet, or 42 miles, of blue-flint banquettes; 12,240 feet, or 8 miles, slate-stone banquettes; 15,840 feet, or 3 miles, Schillinger artificial stone; in all, 279,840 feet, or 53 miles, of stone banquettes.

The following is a statement of the number of miles of stone street pavement: 113,520 feet, or 21½ miles, of Quincy granite square block pavement; 15,840 feet, or 3 miles, of other square-block pavement; in all, 129,360 feet, or 24½ miles.

The greater part of the street pavement is of cobble-stone, brought as ballast; 42 miles of sidewalk pavement are of North River blue-stone; 7 miles of slate.

NEWPORT, RHODE ISLAND.

The materials most used in the better class of stone construction in Newport are Connecticut brownstone and Newport granite. Fort Adams is built of Westerly and Fall River granite, together with some of the local slate. The macadamized Telford road is much used in Newport and the stone employed is the local granite. The foundations and underpinnings are built of Newport granite; the streets are but little paved with stone, and the material used is cobble-stones from Block island and from Nova Scotia. Asphalt manufactured at Providence is much used for street paving. The sidewalks in the business portions of the city are paved with Hudson River flags and asphalt. The curbstones are Hudson River blue-stone and Fall River granite.

NEWTON, MASSACHUSETTS.

The city of Newton includes Newton, Newton Center, Newton Upper Falls, Newton Lower Falls, Newton Valley, West Newton, and Auburndale. Of the stone buildings enumerated three are churches, three private residences, and one mill; one church built of Ohio sandstone was rebuilt from the old Chauncey Street church, Boston. The material for foundations and underpinnings is granite obtained from the bowlders found in the vicinity, with some Westford granite. The streets are not paved with stone; a very few of the sidewalks are paved with Westford granite, with curbs of the same material.

NEW YORK CITY AND ENVIRONS.

By Dr. ALEXIS A. JULIEN.

City.	County.	State.	Population.
New York city	New York	New York	1,206,590
Brooklyn, including Williamsburg and Long Island City	Kings	do	583,806
Castleton, etc. (Staten island)	Richmond	do	40,000
Jersey City, including Hudson City, Bergen City, Bayonne, and Greenville	Hudson	New Jersey	120,728
Hoboken, including West Hoboken, town of Union, and Weehawken	Hudson	do	30,999

This district embraces the principal suburbs of the great metropolis, although the crowded trains and boats which constantly leave all the railroad stations and docks, especially in the morning and evening, point to the outer ring of suburban cities and villages, in the Hudson River counties, on Long island and in New Jersey, whose construction and enlargement chiefly depend for supply of material upon the stone- and brick-yards of New York island.

The statistics embodied have been obtained from many sources, partly by direct counting of houses from street to street, etc., partly by the issue of circulars, and partly by personal application to stone dealers, stone-yards, etc.

The courteous consideration with which, in general, my inquiries have been received calls for my special acknowledgment and thanks to a large number of persons, of whom I ought perhaps specially to name the following: James Wells, insurance agent, 167 Broadway; William E. Midgley, assistant secretary New York and Boston Insurance Company, Howard building, 176 Broadway; J. H. Langford & Co., insurance agents, 10 Pine street; the New York Board of Fire Underwriters; F. Collingwood, engineer in charge of New York approach, New York and Brooklyn bridge; David Acker, deputy commissioner of department of buildings, Brooklyn; James A. Baker, clerk of village of Edgewater, Staten island; J. R. Wardlaw, clerk, etc., Edgewater, Staten island; Miller & Simonson, West New Brighton, Staten island; John H. Cordes, real estate agent, 163 Harrison avenue, Brooklyn; Gill & Baird, John Vesey, Andrew Mills, New England Granite Works, Gillie & Walker, the Bay of Fundy Quarry Company, D. Hotaling, Brander, Boyd & Hutcheon, and Browne, McAllister & Co.

In compliance with my request for specimens of stone, trimmed in accordance with the directions of the building-stone department of the census, many such specimens have been sent to the National Museum at Washington, sometimes with a duplicate intended for the American Museum of Natural History in this city. For these we are specially indebted to the following firms, so far as I have been notified: New England Granite Works, James Morgan & Co., the Bay of Fundy Quarrying Company, and Browne, McAllister & Co.

My report is naturally divided into three parts:

I. The buildings of New York and adjacent cities, etc., their numbers, and common materials.

II. The building stones of these cities, described in some detail, their localities, and examples of edifices constructed of each variety. Public buildings and improvements, with description of materials employed: materials of pavements and roofs; market prices of building stones.

III. Durability of building stones in this district; agents of destruction: elements of strength and durability: methods of trial; means of protection and preservation. (This will form the subject of another chapter, and will be found on pages 364 to 393.

With a field so broad, and with imperfect sources of information, my report can hardly be free from errors and deficiencies: but every effort has been made to avoid them so far as time and opportunity have permitted.

I.—THE BUILDINGS OF NEW YORK AND ADJACENT CITIES; THEIR NUMBERS AND COMMON MATERIALS.

It may be as well to state here that the published maps used by the insurance companies, in which the position and approximately the material of each building are supposed to be laid down, are far from accurate. Not only have the additions and removals of buildings been in some cases imperfectly represented, but on many maps little attempt seems to have been made to exhibit the nature of the material (*i. e.*, of the faces) of the buildings, whether brick or stone. It has been necessary to correct these points, for the purpose of the census, by personal examination of many districts.

The building statistics have been arranged (Table I) to indicate the exact materials of construction in each city, and in an approximate way, the number of buildings erected for special purposes and the selection of materials employed for them. These figures are almost entirely derived from personal inspection and actual counting of the buildings in the several districts. The city of New York comprises an area of 24,893 acres, which may be divided into three great districts, viz:

1. District of wholesale business houses, comprising the entire area of the island south of the line of Canal and Rutgers streets, from the North (Hudson) river to the East river; also the buildings along the line of Broadway up to Fourteenth street.

2. District of small stores and tenements, comprising the area north of the line of Canal and Rutgers streets, and east of the Bowery and Third avenue, up to the Harlem river; also, the entire Twenty-third and Twenty-fourth wards, up to the northern boundary of the city at the Yonkers line.

3. District of large stores and residences, comprising the area north of the line of Canal street, and west of the Bowery and Third avenue, up to the Harlem river at Spuyten Duyvil.

In the city of Brooklyn the lines are much less sharply and easily drawn; however, three districts may be distinguished:

1. District of warehouses, tenements, etc., comprising wards Nos. 2, 4, 5, and 12, and portions of Nos. 1 and 6; *i. e.*, the area bounded by the following line: East river, Hudson avenue to Willoughby avenue; Willoughby avenue to Fulton street; Fulton street to Furman street; Furman street to Atlantic avenue; Atlantic avenue to Hicks street; Hicks street to Cole street; Cole street to Clinton street; Clinton street to Rush street; Rush street to Gowanus bay; along shore of Gowanus bay; Buttermilk channel to Fulton street, East river.

2. District of residences and small stores, comprising the rest of the city, including Williamsburg.

3. District of small residences, comprising the suburb called Long Island City (population 17,117).

The statistics of Jersey City, Hudson county, New Jersey, were gathered in two divisions:

1. Jersey City, including Hudson City and Bergen City, La Fayette, and Communipaw.

2. Bayonne and Greenville.

The statistics of Hoboken, Hudson county, New Jersey, have been gathered under three heads:

1. Hoboken proper.

2. West Hoboken and town of Union.

3. Weehawken.

It has been thought desirable to make this subdivision of the statistics, in reference to these small and, in many cases, at present unimportant places, in view of the enormous growth by which they are liable to be affected in the vicinity of the great metropolis.

Finally, as a matter of general interest, and for the purpose of proper comparison with the other great cities of the world, all the statistics above mentioned have been summed up under the head of New York city and its suburbs.

It may be here noted that a general improvement in the character of the building materials employed is constantly in progress in all these cities, so that the number and proportion of stone buildings have in many cities been sensibly increased since the year 1880; to which date all the statistics in this report, so far as possible, have been made to conform.

A consideration of this table presents the following chief points of interest:

NEW YORK.

Stone enters into the construction, chiefly as fronts, of 11.6 per cent. of all the buildings of the city. Of the entire number of stone buildings, 89.4 per cent. consist of sandstone, and the several varieties of stone occur in the following proportion:

	Per cent.
Brown sandstone	78.6
Nova Scotia and Ohio sandstones	10.6
Marble	7.9
Granite	1.8
Gneiss	0.9
Foreign sandstone	0.1
Blue-stone and limestone	0.1

The materials of general construction in the city occur in the following proportion to the total number of buildings:

	Per cent.
Brick, terra-cotta, stucco, etc.	63.2
Frame, *i. e.*, wooden in part, filled in with brick	24.3
Stone	11.6
Iron	0.9

In the business district brick predominates (77 per cent.), and most of the marble, and somewhat less than half of the iron buildings occur. The remaining iron buildings are mostly found on the large business streets in the other districts.

The tenement district still consists of frame buildings to the extent of 31.7 per cent., nearly half of the entire number in the city. Stone constitutes only 5.5 per cent. of the fronts, though largely employed in the trimmings; and iron and marble are rare. Brick somewhat predominates (62.6 per cent.).

In the residence district brick also predominates (60.9 per cent.), but stone is largely used (14.6 per cent.), including 70 per cent. of all the stone buildings of the city. However, the district comprises, in its unsettled and

partially-built areas, the greater part (55 per cent.) of the wooden buildings of the city. Here most of the stucco buildings occur, but their number (166) is very small, particularly in comparison with their abundance in the metropolis of England.

BROOKLYN.

Stone is here employed in a proportion (9 per cent.) a little less than that of New York (11.6 per cent.), and in much less variety, the Connecticut brownstone predominating (95.7 per cent.) in the entire number of stone buildings. This stone is employed altogether for the residences throughout the city. Very few iron buildings occur, but there are over three times as many stucco fronts as there are in New York. The frame buildings constitute half of the entire number (50.9 per cent.), especially predominating in the outskirts, as in Long Island City (80.5 per cent).

STATEN ISLAND.

Stone enters in a very small proportion into the construction of fronts of buildings on this island (5 per cent.), though it is commonly employed for trimmings, walls of inclosures, and other masonry. Brick is largely employed, especially in the towns and villages (9.5 per cent.), but the common material is wood (90 per cent).

JERSEY CITY.

In the suburbs of this city the proportions of stone and brick employed are very similar to those on Staten island. But in Jersey City proper the predominance of frame houses is much less, the buildings amounting to 1.9 per cent., and the brick to 25.9 per cent. The selection of the dark trap-stone from the heights behind the main city for the construction of many fronts or of entire buildings is a peculiar local feature.

HOBOKEN.

The materials of construction in the suburbs of this city, upon the top of the trap ridge, etc., are similar in proportion to those on Staten island and in the suburbs of Jersey City. In Hoboken proper the proportion of stone buildings is large (3.9 per cent.), and the brick buildings constitute over half (52.7 per cent.) of the entire number.

THE METROPOLIS.

Finally, in regard to the whole district, it will be seen from the table that stone enters into the construction of the fronts of 9.1 per cent. of all the buildings of this city, though it is employed otherwise to an enormous extent for foundations, trimmings, walls, copings, stoops, etc. I have not been able to obtain sufficient data for the estimation of the entire import of stone into the city; but some idea of the vast expenditure involved in the construction of our buildings may be derived from the reports of the superintendents of the building departments of New York and Brooklyn, and have suggested the following by a writer in the *Am. Arch. and Building News*, 1878, Vol. III, page 71:

> It would seem from it that the average cost of a new building in New York city has been $13,741, and that with some additions of work, not formerly reported to the superintendent, the aggregate sum spent in adding to the plant and material on Manhattan island has reached the enormous sum of about $350,000,000.

From the annual reports of the committee on the fire patrol to the New York board of fire underwriters, of 1881 and 1882, the statistics given below have been extracted:

Number of buildings in New York city south of Fifty-ninth street:		
South of Canal street, west of Broadway	3,555	
South of Canal and Rutgers streets, east of Broadway	6,998	
		10,553
Lower district, south of Canal street:		
Between Canal and Fourteenth streets, west of Broadway	10,219	
Between Canal and Fourteenth streets, east of Broadway	16,481	
		26,700
Lower central district, between Canal and Fourteenth streets:		
Between Fourteenth and Fifty-ninth streets, west of Fifth avenue	20,559	
Between Fourteenth and Fifty-ninth streets, east of Fifth avenue	13,256	
		33,815
Upper central district, between Fourteenth and Fifty-ninth streets:		
North of Fifty-ninth street, west of Fifth avenue	6,372	
North of Fifty-ninth street, east of Fifth avenue	12,374	
Upper district, between Fifty-ninth street and Harlem river		18,746
New York city, Battery to Harlem river		89,814

The area comprised by the enumeration does not include that of the Twenty-third and Twenty-fourth wards north of the Harlem river, and the total, therefore, falls below that of the last column of the table given on page 329. The materials of construction are reported as follows:

Brick, with stone trimmings and in part with stone facings	64,783
Brick and frame	3,616
Frame	21,415
Total	89,814

Of this number the stores amount to over 5,300, whose value, at an average of but $100,000 each, might be estimated at $53,000,000.

Another enumeration of the number of buildings in New York city is now being carried on by committees of the fire department, but will not probably be completed for many months.

II.—THE BUILDING STONES.

A. VARIETIES, LOCALITIES, AND EDIFICES.

The series of buildings employed in New York and adjacent cities is rich and varied, comprising materials derived by water carriage from most of the sea-ports of New Brunswick and New England, and from many points along the Hudson river, and by railway from the interior of all the New England and middle states, even as far west as Indiana.

The only careful description of our American building stones yet made is found in the report of Dr. J. S. Newberry on the building stones displayed at the exposition at Philadelphia in 1876, and it will suffice for the object of this report to quote freely from the descriptions of varieties there given. It may be also remarked that from time to time various building stones have been brought to this market from numerous quarries of limited extent which have soon become exhausted; *e. g.*, the granite from Dix island. So large is the number of building stones, and so scattered are the sources of information concerning them, that some of subordinate importance may very likely not be included in the following list. In most cases prominent examples are given of the use of stone in the larger or public buildings of the city, both as ashlar for fronts and as the trimmings of buildings mainly constructed of brick.

The materials most commonly in favor for facings of the fronts of our buildings consist of red pressed brick, which is glaring and offensive to the eye; white marbles, which are at first too bright, but soon assume a dirty cream-colored tinge of discoloration; drab or olive-gray freestones, which rapidly become discolored by blackish-gray stains on fronts exposed to the north and east, and brown freestones or brownstones, very generally used for the ashlared fronts of residences. This latter stone presents rather a somber and cheerless aspect under a cloudy sky on a winter day, and imparts a great monotony to the appearance of our cross-streets; nevertheless, under the bright sky and brilliant atmosphere of many days of spring and winter, and above all of the summer in New York, it is not trying to the eye nor glaring like brick or marble or the light-colored granites and freestones.

The following details have been gathered partly from my own observation and that of my assistants, but for many particulars, especially in regard to examples of construction, I have been indebted to various persons, and I have not been able to verify them all:

Freestone (sandstone).—Shepody mountain, Hopewell, Albert, New Brunswick. Pale olive-green, and of medium fineness; uniform texture and tint, and of good strength; is a durable and serviceable stone, generally admired for its color (J. S. Newberry). Derived from the Millstone Grit formation. Examples of construction. (See Freestone of Dorchester, New Brunswick.)

Freestone (sandstone).—Mary's Point, Albert, New Brunswick. Colors, salmon, olive, and dark brown. Derived from the Lower Carboniferous formation. Examples of construction: The Reformed church, corner of Fifty-seventh street and Madison avenue; the fence surrounding Central park, the bridges, fountain, basin, and most of the freestone masonry in the park; also the similar masonry in Prospect park, in Brooklyn.

Freestone (sandstone).—Wood Point, Westmoreland county, New Brunswick. Color, dark brown. Examples of construction. (See below.)

Freestone (sandstone).—Sackville, New Brunswick. Derived from the Lower Carboniferous formation. Examples of construction. (See below.)

Freestone (sandstone).—Harvey, New Brunswick. Derived from the Lower Carboniferous formation. Examples of construction. (See below.)

Freestone (sandstone).—Dorchester, New Brunswick. Derived from the Lower Carboniferous formation. Examples of construction: Stoops and part of trimmings of Normal college, Sixty-eighth street and Lexington avenue; building of New York Historical Society, corner of Second avenue and Eleventh street; part of the wall and bridges in Central park. Trimmings of the Academy of Music, Montague street, Brooklyn.

Freestone (sandstone).—Weston, New Brunswick. Derived from the Lower Carboniferous formation. Examples of construction: Part of the wall and bridges in Central park.

FREESTONE (sandstone).—Kennetcook, Hants county, Nova Scotia. Colors, olive and blue. Derived from the Lower Carboniferous formation. It is also used for grindstones. Examples of construction. (See below.)

General examples of the construction in the "Nova Scotia" stone: Church in Twenty-fifth street, east of Fifth avenue; hotel Bristol, Forty-second street, near Fifth avenue; churches: Madison avenue, near Fifty-seventh street; Fourteenth street, west of First avenue; Fourteenth street, west of Sixth avenue; Fifteenth street, east of Third avenue; Sixth avenue, near Fifteenth street; Twenty-first street, east of Second avenue; Thirty-fourth street, east of Seventh avenue; Forty-second street, west of Seventh avenue; Lexington avenue, near Forty-sixth street; Lexington avenue, near Sixty-third street; Seventy-sixth street, east of Third avenue; Eighty-ninth street, east of Madison avenue; bank, Broadway, Brooklyn.

FREESTONE (sandstone).—East Longmeadow and Springfield, Massachusetts. Derived from the Triassic formation.

FREESTONE (brown sandstone or brownstone).—Portland, Connecticut. "Some varieties are laminated in structure and liable to exfoliate when used as ashlars and set on edge." This stone imparts a somber monotony of tone to the architecture of our cities. Color light to dark reddish-brown, inclining to chocolate; texture varying widely in fineness, but usually coarser than the similar freestone from Belleville, New Jersey. Examples of construction are abundant in the residences throughout our cities, *e. g.*, on the northwest corner of Fifty-seventh street and Fifth avenue: Academy of Design, in Brooklyn, Montague street, west of Fulton.

FREESTONE (sandstone).—Middletown, Connecticut. Derived from the Triassic formation. Examples of construction: Trinity church, corner of Clinton and Montague streets, and the Methodist Episcopal church, on northwest corner of Clinton and Pacific streets, in Brooklyn.

RED SANDSTONE.—Potsdam, New York. The oldest of all the sandstones, belonging to the Potsdam period of the Lower Silurian formation. Color, a warm reddish brown, slightly mottled and striped with white; structure, decidedly laminated, in thin parallel sheets, often crossed obliquely by obscure fissure lines of lighter color. It is quite refractory, and has been used for lining of iron furnaces. Examples of construction: Quoins, trimmings, and basement of residence in Fifth avenue, near Thirty-fifth street; dressings, string-courses, etc., of building of Columbia college, Forty-ninth street and Madison avenue.

BROWN SANDSTONE.—Oswego, New York. Example of construction: Part of first story of Masonic temple, Twenty-third street and Sixth avenue.

FREESTONE (brownstone).—Newark, New Jersey. Examples of construction: Churches on corner of Forty-eighth and Fifty-fifth streets and Fifth avenue; the synagogue, on Fifth avenue; church on corner of Madison avenue and Fifty-fifth street; Trinity Church school, on Church street; Trinity chapel, on Houston street; trimmings of buildings at Thirty-second street and Broadway, etc.

FREESTONE (sandstone or "brownstone").—Belleville, New Jersey. Derived from the Triassic formation. Colors, brownish-gray, light brown, light reddish-brown, and light orange-brown. Generally finer grained and more compact than the stone from Connecticut. Examples of construction: House on northeast corner of Fiftieth street and Madison avenue; Church of the Messiah, northwest corner of Thirty-fourth street and Park avenue; trimmings of many residences in Madison avenue, *e. g.*, on northwest corners of Sixty-seventh, Sixty-eighth, and Sixty-ninth streets, etc.; Baptist Church of the Epiphany, southeast corner Madison avenue and Sixty-fourth street; two shades of this stone presented in the church and chapel, Madison Avenue Methodist Episcopal church, northeast corner Madison avenue and Sixtieth street; Presbyterian church, corner Fifty-fifth street and Fifth avenue; Jewish temple, corner of Fifty-fifth street and Lexington avenue, with trimmings of Ohio stone; trimmings of Harney building, 16 Wall street; Seventh Ward bank; Mills building, corner Broad street and Exchange place, and many bridges in Central park; Fort La Fayette; houses on corner of Fifty-seventh and Ninety-third streets and Fifth avenue, and corner of Twenty-eighth street and Madison avenue.

FREESTONE (brown sandstone).—Little Falls, New Jersey. Derived from the Triassic formation. Example of construction: Trinity church, Broadway and Wall street.

FREESTONE (brownstone).—Base of Palisades, New Jersey. Derived from the Triassic formation. Example of construction: Part of the wall in Central park.

FREESTONE (brownstone).—Hummelstown, Pennsylvania. This has been largely used in Philadelphia, and is said to be an excellent variety. Example of construction: Building on Fifth avenue, above Forty-first street.

FREESTONE (sandstone).—Amherst, northern Ohio. Belonging to the Lower Carboniferous or Waverly series. Fine grained, homogeneous sandstone, light drab in color, made up chiefly of grains of quartz; color, permanent. An excellent building stone. Example of construction: Building corner of Barclay street and Broadway, erected twenty years ago.

FREESTONE (sandstone).—East Cleveland, Ohio. Color, drab and dove-colored. Derived from the Waverly and Coal Measures.

FREESTONE (sandstone).—Independence, Ohio. Color, light drab, and coarser than the stone of Amherst. Derived from the Waverly and Coal Measures.

FREESTONE (sandstone).—Berea, Ohio. Derived from the Waverly and Coal Measures. Not quite so fine grained as the Amherst; a light bluish-gray, generally a strong and durable stone, sometimes liable to discoloration

by decomposition of pyrites. Examples of construction: New York *Clipper* building; block on corner of Cliff and Fulton streets; Church of Transfiguration; west side of Sixth avenue, above Twenty-seventh street; Decker's building, in Union square; churches: One hundred and ninth street, near Madison avenue; One hundred and sixteenth street, near Third avenue; South Fifth street, near Canal; Bond building, on Broadway, next Trinity building; front of Rossmore hotel, Forty first street and Broadway; trimmings of house, northwest corner of Forty-third street and Madison avenue; Williamsburg Savings bank, corner Broadway and Fifth street, Brooklyn, eastern district (with basement and pilasters of Quincy granite); Berea hall, Brooklyn, etc.

BUENA VISTA FREESTONE (sandstone).—Portsmouth, Scioto county, Ohio. This belongs to the lower part of the Waverly series. It is finer grained and less siliceous than that from northern Ohio, "and has generally a more decided bluish tint when freshly quarried, but becomes lighter and more yellowish on exposure." It varies in color from brown, dove-colored, banded and mottled red and yellow to black.

Though some varieties of this stone are liable to stain and exfoliate, from the oxidation of the contained iron, as a general rule it is an excellent and very handsome stone, taking rank with the best and handsomest of the freestones of the country.—J. S. N.

FREESTONE (sandstone).—Waverly, southern Ohio. Derived from the lower part of the Waverly series.

Within a few years a considerable quantity of stone, which is known in New York by the name of "Carlisle" or "Scotch" stone, has been brought into New York as ballast. It is not the English stone known by the former name in England, but comprises three varieties of Scotch sandstone, here called merely by the name of the English port at which the stone is shipped, Carlisle. Each stone will be separately considered:

1. CORSEHILL FREESTONE (sandstone).—Corsehill, near Annan, in Dumfries county, about 60 miles west of Glasgow, Scotland. Derived from the new red sandstone. Color, dark red to bright pink; close grained; weathers well, works easily, fit for ashlar, and well adapted for carving and for columns. Examples of construction: Trimmings of Murray Hill hotel, Park avenue and Forty first street; stables on south side of Sixty-second street, between Park and Madison avenues; house corner of Fifty-seventh street and Fourth avenue; mantels in residence corner of Fifty-second street and Fifth avenue; trimmings of the Berkshire building, northwest corner of Madison avenue and Fifty-second street.

2. BALLOCHMILE FREESTONE (sandstone).—Ballochmile, Forfarshire, Scotland. A little darker in color than the Corsehill stone. Derived from the Carboniferous formation. Examples of construction: Two houses in west Seventy-eighth street; house in Fifty-seventh street and Seventh avenue.

3. RED FREESTONE (sandstone).—Gatelaw bridge, 30 miles from Ballochmile, Dumfriesshire, Scotland. About equal in quality and perhaps superior in beauty to the Corsehill stone, but much superior to the Ballochmile stone. Example of construction: The only building constructed of this stone is the house on southeast corner of Forty-second street and Fifth avenue.

RED SANDSTONE.—Frankfort-on-the-Main, Germany. Example of construction: Building in Sixty-eighth street, east of Third avenue.

BLUE-STONE (graywacke).—Albany, Delaware, and Greene counties, New York. The Greene County stone is obtained from some heavier beds in the Portage group, along the base of the Catskill mountains, and is shipped at Malden, on the Hudson river.

It is one of the very best flagging stones in the world. It may be quarried in slabs of almost any desired thickness or dimensions, the different layers varying much in this respect. The natural surfaces of these strata are comparatively smooth, and form a good walk without dressing. The stone comes from the Hamilton group of the Devonian system, and forms a belt of outcrop extending from Kingston on the Hudson to Port Jervis on the Erie railroad, and thence southward. It is a fine-grained sandstone, generally dark blue in color—whence its name—and is very strong and durable. When ground or sawed it forms a very smooth surface, and yet one that always has a tooth or grain which holds the foot well, whether wet or dry. In this respect sandstones are much superior to granites and limestones, which become slippery and dangerous when wet.—J. S. N.

Examples of construction: Part of the bridges and wall in Central park.

MONTROSE STONE (blue-stone).—Kingston, Ulster county, New York. A variety more pinkish in color than ordinary blue-stone, but about the same in hardness and general characteristics. Examples of construction: Two stables in Fifty-first street, between Seventh and Eighth avenues; penitentiary on Blackwell's island; flooring of casemates in forts of the harbor; trimmings of National Academy of Design, Twenty-third street and Fourth avenue (with casing); porch of house, 15 East Thirty-sixth street; house in Fifty-seventh street, two doors west of Fourth avenue.

WYOMING BLUE-STONE (graywacke and flag-stones).—Pond Eddy, Long Swamp, the Narrows, Lackawaxen, near and in Pike county, Pennsylvania, and across the Delaware river in New York. This stone is mostly shipped to Rondout by the Delaware and Hudson canal. Thickness of the flags and beds, from 2 to 18 inches. It is used for window- and door-sills, step-stones, water-tables, platforms, cellar, prison, and casemate floors, sidewalks, curbs, gutters, the bases of tombstones, candy tables, etc.

The blue-stone is the best; when it is struck with the hammer it has a metallic ring; and the finer the grain of the stone the better, because it is more apt to be smoother, tougher, harder, and truer over the face than a coarse-grained flag.—*The Manufacturer and Builder*, 1876, VIII, 138.

Examples of construction: The basement of residences, Thirty-fourth and Fifty-eighth streets; a building in Seventeenth street, on Stuyvesant square; trimmings of Produce Exchange building.

FREESTONE (limestone)—CAEN STONE (oolite) CAEN.—Normandy, France. This stone is of a pale cream-yellow color, of a loose, open grain, soils the fingers like chalk, and is very friable. It is very soft when first quarried, but hardens on exposure; is easily worked, sawed and carved, but weathers very badly; weighs from 116 to 142 pounds to the cubic foot. Examples of construction: The former Nassau bank, corner of Nassau and Beekman streets, built in 1828; the reredos in Trinity church; the Tontine building; six residences in West Ninth street, between Fifth and Sixth avenues, erected in 1857; the dormitory in Sixteenth street, adjoining the New York hospital on the Fifth Avenue side; house next to church, Fifth avenue and Twenty-ninth street; the plinths, bands, and cornices of church and parsonage on southeast corner of Nineteenth street and Fourth avenue; bands, mullions, etc., of oriels and general trimmings in Trinity chapel.

LIMESTONE.—Lockport, New York.

This comes from the encrinital layer of the Niagara group, and is a gray limestone thickly set with fossils, most of which are the joints of crinoids. Some of these are tinged with red, while others have a blue or opalescent shade, all of which give an agreeable variety to the color of the stone. It is less hard than the true marbles, and as a consequence takes a less brilliant polish and is more easily scratched. When properly wrought, however, it is quite handsome, and is considerably used for mantels and other purposes.—J. S. N.

Examples of construction: Lenox library, Fifth avenue and Seventieth street, and the dressings of apertures, bands, posts, etc., of the Presbyterian hospital, Madison avenue and Seventieth street.

OOLITIC LIMESTONE.—Ellettsville, Monroe county, Indiana. Example of construction: Office building in Cortland street, next to Coal and Iron Exchange building.

OOLITIC LIMESTONE ("Indiana limestone" or "Bedford stone").—Bedford, Lawrence county, Indiana. Examples of construction: Residences on northwest corners of Fifty-second and Fifty-seventh streets and Fifth avenue; Smith building, Cortland street; lowest story of Appleby Flat building, at Seventh avenue and Fifty-ninth street, and a similar building at Eleventh avenue and Eighty-fourth street; Bridge building, Fourteenth street; rectory, on Fifty-fifth street.

LIMESTONE.—Kingston and Rondout, New York. Examples of construction: Part of anchorages, approaches, and base of towers of New York and Brooklyn bridge.

LIMESTONE.—Isle La Motte, lake Champlain. Examples of construction: Part of the anchorages and towers of New York and Brooklyn bridge.

LIMESTONE.—Willsborough point, lake Champlain, New York. Examples of construction: Part of anchorages, approaches, and base of towers of New York and Brooklyn bridge.

LIMESTONE.—Greenwich and Mott Haven, Connecticut. Examples of construction: Part of wall in Central park.

GRANITE.—Bay of Fundy, Nova Scotia.

It contains almost no mica; is of moderately fine grain, the groundwork composed of a bright, light red orthoclase, mottled with perhaps one-fourth of the quantity of bluish quartz, and one-tenth or less of black hornblende. It is a very tough and compact rock, and takes as high and uniform a polish as any other variety of granite known.—J. S. N.

Examples of construction: The columns of the Stock Exchange building.

RED GRANITE.—Calais, Maine.

It is composed of pale red orthoclase, with a smaller quantity of a lighter feldspar, possibly albite, with quartz, hornblende, and a little mica. It takes a fine polish, is homogeneous in texture and color, and well deserves the good reputation it enjoys.—J. S. N.

GRANITE.—Bluehill, Maine. Light gray in color, and of good texture. Example of construction: The United States barge-office, Battery.

GRANITE.—Morgan's bay, East Bluehill, Maine.

A compact, homogeneous, light gray granite, composed of relatively large crystals of white orthoclase, with fine grains of glassy quartz and specks of black mica. In color it is one of the lightest of New England granites, and from the preponderance of feldspar, the absence of hornblende, and the granular condition of the quartz, it will work with unusual facility and will prove a handsome and durable stone.—J. S. N.

The stone is handsomely mottled and susceptible of a high polish. Examples of construction: Part of the towers and approaches of the New York and Brooklyn bridge.

GRANITE.—Spruce Head, near Rockland, Maine.

A clear, mottled, white and black syenite, which consists of nearly equal parts of snow-white orthoclase, glassy quartz, and black hornblende. The constituents are firmly united, making it a strong and durable stone, which takes a brilliant polish. The quantity of hornblende in it and the striking contrast in color between this and the feldspar give it a peculiar bright lively tint, which renders it one of the handsomest of the gray granites.—J. S. N.

Examples of construction: Part of towers of New York and Brooklyn bridge; bridges of Fourth Avenue improvement; Jersey City reservoir; hospital building for Sailors' Snug Harbor, Staten island.

RED GRANITE.—Red Beach, Maine.

This is a fine-grained granite, of which the general complexion is reddish, but less positively so than that of most so-called red granites. It is composed of pale red and creamy white feldspar, with smaller masses of smoky quartz, fine grains of black hornblende, and specks of black mica. It takes a good polish and is undoubtedly a strong and durable stone. In quality it will take equal rank with the Jonesboro, and Calais red granites, from which it differs chiefly in its greater fineness of mottling.—J. S. N.

GRANITE.—Hurricane island, Maine. A gray stone of good quality and susceptible of high polish. Examples of construction: Portions of the New York docks; part of the towers and approaches of the New York and Brooklyn bridge; part of the New York post-office.

GRANITE.—East Boston, Fox island, Maine.

A very fine grained stone, having the general complexion of the Westerly granite, but differing from that by showing a faint pinkish blush in its feldspar. In this respect it resembles the "harbor granite" of Fox island, of which it is indeed only a fine-grained variety.—J. S. N.

GRANITE.—Deer island, Maine. A light gray and biotitic granite. Example of construction: The grain elevator of the New York Central Railroad.

GRANITE.—Vinal Haven, Maine. Light gray and rather coarse. Examples of construction: Sailors' Snug Harbor, Staten island; the Butler monument at the mausoleum in Greenwood cemetery, etc.

GRANITE.—Saint George, Maine. Fine-grained and compact. Example of construction: The pedestal of the La Fayette monument at Union square.

GRANITE.—Augusta, Maine. A compact and fine-grained granite, containing both muscovite and biotite, and capable of receiving a good polish. Examples of construction: Mills' building, corner of Broad street and Exchange place; monument to Recorder Hackett; Roberts tomb in Woodlawn cemetery; Wood's tomb in Greenwood cemetery, etc.

GRANITE.—Biddeford, Maine. Examples of construction: A railroad elevator in Jersey City; docks along the North river, etc.

GRANITE.—Pownal Centre, Maine. Sometimes used for paving in New York city.

GRANITE.—Harbor, Fox island, near Rockland, Maine.

A coarse-grained, handsome mottled granite, composed of very pale pink and white feldspar, mingled with relatively fine grains of quartz and hornblende. Its general tone of color is reddish gray blotched with white, and quite pleasing to the eye. It takes a good polish.—J. S. N.

Examples of construction: Part of the towers of the New York and Brooklyn bridge; the basement of the Stock Exchange building.

GRANITE.—Hallowell, Maine.

A very light, fine-grained stone, consisting chiefly of white orthoclase feldspar, with relatively fine grains of glassy quartz, specks of black hornblende, and minute scales of silvery mica. This latter gives the stone a peculiar glitter and adds greatly to its beauty without seriously affecting its strength. Dressed surfaces are almost as white as white marble, and, where polished, the spangles of mica buried beneath the surface reflect the light and sparkle like diamonds. From the small quantity of quartz and the presence of mica, the Hallowell granite works with usual facility, both in the quarry and under the chisel; yet it takes a good polish and is as strong and will prove as durable as most of the esteemed varieties of this stone.—J. S. N.

Examples of construction: Finish of door-jambs, windows, etc., of Saint Patrick's cathedral, Jersey City heights; Ludlow street jail; the *Tribune* building; the "Halls of Justice" or "Tombs" prison, in Centre street.

GRANITE.—Round Pond, Maine. A dark gray and compact biototic granite. Example of construction: The Seventh Regiment armory.

GRANITE.—Clark's island, Maine.

GRANITE.—Mount Waldo, Maine.

GRANITE.—Musquito mountain, Maine.

GRANITE.—Jonesboro', Maine. Examples of construction: Part of the panels at entrance of Williamsburg Savings bank, Brooklyn; the front of Welles building, on the corner of Broadway and Beaver streets, New York; the Hunnewell building, etc.

GRANITE.—Frankfort, Maine. A coarse, compact, and generally porphyritic gray biotitic granite. Example of construction: Part of towers and approaches of New York and Brooklyn bridge.

GRANITE.—Mount Desert island, Maine. A light gray biotitic granite. Examples of construction: Part of towers and of the Brooklyn approaches of the New York and Brooklyn bridge; Metropolitan Museum of Art; fort Schuyler, etc.

GRANITE.—Radcliffe's island, Maine. Examples of construction: Bridges in Central park.

GRANITE.—Dix island, Maine. A dark gray, compact granite. This quarry is now exhausted. Examples of construction: New York post-office; first base-course of Saint Patrick's cathedral; court-house in City Hall park; part of *Staats Zeitung* building; fortifications in the harbor; docks at Castle Garden, and the retaining-walls for the basin and barge-office.

GRANITE.—Concord, New Hampshire. Examples of construction: Booth's theater; German Savings bank, corner Fourteenth street and Fourth avenue (basement, Quincy granite); part of towers and approaches of New York and Brooklyn bridge.

GRANITE.—Saint Johnsbury, Vermont.

A gray stone of excellent quality and established reputation.—J. S. N.

GRANITE.—Bethel, Vermont.

A nearly white granite of a homogeneous texture, but not highly polished. It must be an admirable stone for special uses, but it is probably less durable than some of the more siliceous and compact varieties.—J. S. N.

GRANITE.—Barre, Vermont.

This stone has been proved by ample trial to be an excellent stone for architectural and monumental purposes. It is light gray in color, of medium fineness, very homogeneous, and firm.—J. S. N.

GRANITE.—Cape Ann, Massachusetts. Example of construction: The dark base stone and spandrel stones of the towers and approaches of New York and Brooklyn bridge.

GRANITE.—Quincy, Massachusetts.

A well-known stone consisting of quartz, feldspar, and hornblende without mica. The color varies considerably, and affords opportunity for the exercise of taste in combination and adaptation to different purposes. This variation of color is due to differences in the feldspar of the different beds. In one it is pale green, in another purplish-blue, and in the third pale pink. The black hornblende, which exists in considerable quantity, is the same in all, as is also the glassy quartz. The stone is susceptible of a high polish, and its strength and durability are amply attested by the trials to which it has been subjected. As a whole the Quincy granite is rather somber in tone, and on this account is for many purposes less desirable than the lighter varieties.—J. S. N.

Examples of construction: The Astor house; Reformed church, in La Fayette place, corner of Fourth street; custom-house, Wall street, corner of William; part of trimmings of Normal college, and Hahnemann hospital, Fourth avenue and Sixty-seventh street; part of *Staats Zeitung* building; Tryon row, between Center and Chatham streets.

GRANITE.—Westerly, Rhode Island.

This is a remarkably fine grained homogeneous stone, chiefly composed of pale-pinkish or brownish-white orthoclase and thickly set with minute grains of black hornblende and occasional specks of black mica. It takes a fine polish, and is justly esteemed as one of the best granites in the country.—J. S. N.

One variety is decidedly pinkish in color; the others gray, fine, and coarse-grained; all of good quality. Also red, white, and blue varieties. Example of construction: Part of Brooklyn anchorage of the New York and Brooklyn bridge.

GRANITE.—Thomaston, Connecticut.

It is lightest in color of all the granites exhibited at Philadelphia; is fine-grained, compact, and homogeneous, and is a remarkably beautiful and excellent stone, specially adapted to monumental work, for which it is largely used and highly esteemed.—J. S. N.

GRANITE.—Millstone point, Connecticut.

A dark gray granite of fine, homogeneous texture, showing strong contrast of color between polished and dressed surfaces.—J. S. N.

GRANITE.—Leetes island, Connecticut.

It is a reddish-gray, rather coarse-grained gneiss; a handsome building stone, but taking an imperfect polish, and is not well adapted to ornamental purposes.—J. S. N.

Example of construction: Bridge over Harlem river.

GRANITE.—Mystic Bridge, Connecticut.

A very fine grained, light to dark gray granite, homogeneous in texture, and handsome.—J. S. N.

GRANITE.—Stony Creek, Connecticut.

Pale red in color, of medium grain, and consists of flesh-colored orthoclase, greenish-white oligoclase, and glassy quartz, with specks of black hornblende and magnetic iron. Minute points of pyrites may also sometimes be seen in it. It is a strong, compact, and handsome stone, having an agreeable tint, taking a high polish, and has been proved by trial to be well adapted for both construction and ornament.—J. S. N.

Another variety is a gray, fine-grained stone of good quality. Example of construction: Part of New York anchorage of the New York and Brooklyn bridge.

GRANITE.—Umpewaug, Norwalk, Connecticut.

This is a rather fine grained, pinkish gray granite, homogeneous and compact; a good building stone.—J. S. N.

RED GRANITE.—Lyme, Connecticut.

Very coarse grained, composed mostly of pale red or flesh-colored feldspar mottled with a whiter variety and glassy quartz; it is also specked and streaked with hornblende. From the preponderance of coarsely crystallized pale red orthoclase in its composition, it has a more uniform tint than any other red granite shown in the exhibition, and on this account, should it prove sound and strong, it will be a valuable addition to the varieties now in use for architectural and ornamental purposes.—J. S. N.

GRANITE.—Niantic, Connecticut. Light gray and fine grained. Example of construction: Reservoir in Central park.

GRANITE.—Saint Lawrence county, New York. Derived from the Laurentian formation.

GRANITE.—Cornwall, New York (highlands of Hudson river). Derived from the Laurentian formation.

GRANITE.—Charlottesburg, New Jersey. Example of construction: Part of the New York anchorage of the New York and Brooklyn bridge.

GRAY GRANITE (Aberdeen granite).—Rubislaw, near Aberdeen, Aberdeenshire, Scotland. This occurs in large blocks, takes a fine polish, and is grayish in tint. It is of metamorphic origin, according to Haughton, and consists of quartz, orthoclase, and black mica. The city of Aberdeen is built from it.

GRAY GRANITE (Aberdeen granite).—Rubislaw, near Aberdeen, Aberdeenshire, Scotland. This stone is considered the best granite adapted as pavement for the traffic of London, as it is very durable and less slippery than most other granites. It was used in England in the London pavements, the Portsmouth and Sheerness docks,

Bell Rock light house, Waterloo bridge, and upper side of London bridge, and in many polished columns and stones of buildings throughout New York city, Brooklyn, etc. Its weight per cubic foot varies from 165 to 166 pounds.

RED GRANITE (Peterhead granite).—Sterling Hill, near Peterhead, 30 miles from Aberdeen, Scotland. This is the best and most beautiful of the granites of Scotland. Its weight per cubic foot is about 166 pounds. It is used in the columns and building stones of numerous edifices in all the cities of Great Britain, where it is justly esteemed for the beauty of its color, closeness of texture, and the large blocks it yields from the quarry. It contains red orthoclase, albite, black mica, and quartz, and has been considered eruptive by Dr. Haughton.

British examples of construction: Pillars of Carlton club-house; the Fishmongers' hall, London. Columns for interior of Saint George's hall, Liverpool. Columns in Provincial Bank of Ireland, Dublin.

The Scotch granites are justly esteemed for their beauty of color and closeness and uniformity of texture. * * * The popularity of the Scotch granites, excellent as they are, is not due however to any superiority over the granites of the United States, but rather to their early occupation and subsequent possession of the market. No stronger or more durable stone is likely to be found anywhere than the granites of Peterhead and Aberdeen, but they do not surpass in beauty or excellence the red granites of the Bay of Fundy and Gananoque, and the more esteemed varieties of red and gray granite from New England.—J. S. N.

Examples of construction in the United States: Many polished columns and stones in the fronts and entrances of many buildings throughout New York, Brooklyn, etc.

SYENITIC GRANITE.—The granite of Syene, syenite rose of Egypt, occupies large tracts in Upper Egypt between the first cataract and the town of Assouan, the ancient Syene, including several islands both above and below the cataract. It was extensively quarried by the Egyptians as far back at least as the reign of Zestos, king of Thebes, one thousand three hundred years before the Christian era, and fashioned into columns, obelisks, sarcophagi, and colossal statues which have lasted with but little injury down to the present day, and adorn the cities and public galleries of modern Europe. These quarries may still be traced at intervals, and the marks of the pick and chisel are still fresh. * * * It consists of large crystals of red orthoclase, sometimes in twins, and porphyritically developed, a little yellowish oligoclase, quartz, and dark mica, with occasionally a little hornblende. Sometimes the orthoclase crystals are of very large size, and the whole rock extremely coarse grained. The general color of the rock is reddish, and it takes a fine polish.

The analyses of Egyptian granite (or "syenite"), from a fragment of an antique in the collection of the Louvre, Paris, by Professor Delesse, yielded the following results: Silica, 70.25 per cent.; alumina, 16.00; oxides of iron and manganese, 2.50; lime, 1.60; magnesia, potash, and soda, 9.00; water, 0.65. Examples of construction: The obelisk and pedestal in the Central park, New York city. The masonry at the base of the pedestal consists of nummulitic limestone from Egypt.

GNEISS.—New York island. This rock occurs in two common varieties: the one biotitic, fine-grained, often slaty, bluish-gray in color, and consisting of quartz, plagioclase, feldspar, biotite, with more or less garnet, magnetite, fibrolite, etc.; the other, hornblendic, black, glistening, slaty, and differing from the former chiefly in a large content or predominance of black hornblende. Examples of construction: The foundations of most of the buildings of the city; side walls of Saint Paul's church, corner of Broadway and Fulton street; church, Thompson street near Prince; Church of the Strangers, Mercer street, near Clinton place; All Saints church, Henry street, near Seamel street; Henry Street church, Henry street, near Market street; church, Henry street, near Rutgers street; church, Centre street, corner of Broome; basement of Irving hall, on southwest corner of Irving place and Fifteenth street; church, Twentieth street, west of Eighth avenue; church, Twenty-third street, east of Third avenue; Bellevue hospital, Twenty-seventh street, east of First avenue; church on southeast corner Thirty-eighth street and Madison avenue; asylum for the blind, Thirty-third street, near Ninth avenue; church, Thirty-fourth street, east of Seventh avenue; church, Madison avenue, near Thirty-eighth street; church, Forty-fourth street, east of Tenth avenue; church, northeast corner of Forty-seventh street and Madison avenue; church, Fifty-third street, east of Sixth avenue; church, Seventy-second street, near Third avenue; church, Seventy-fourth street and Fourth avenue; church, One hundred and seventeenth street, near Fourth avenue; church, One hundred and twenty-seventh street, near Lexington avenue; part of church of the Holy Spirit, corner Sixty-sixth street and Madison avenue; first story of Berkshire building, on northwest corner of Fifty-first street and Madison avenue; basement of New York foundling asylum, on southwest corner Third avenue and Sixty-ninth street; New York Juvenile Asylum, One hundred and seventy-eighth street (Kingsbridge road); Saint Ann's Avenue church, One hundred and fortieth street; church, Third avenue, near One hundred and forty-sixth street; Saint John's college, Fordham; cemetery office, Woodlawn; Methodist church, Washington place; church on northwest corner Washington place and Sixth avenue; Croton aqueduct, and the reservoirs at Fifth avenue and Forty second street, and in Central park (quarried from site); Church of Saint Paul the Apostle, Ninth avenue and Fifty-ninth street (facings, red Connecticut granite); foundations of the Lenox hospital, Seventieth street and Madison avenue; basement of the Berkshire building, northwest corner of Madison avenue and Fifty-second street; the tower, bridges, and walls in Central park.

GNEISS.—Westchester county, New York. Examples of construction: Many bridges and walls in Central park.

GNEISS.—Willett's Point, Kings county, New York (Long island, on the shore of the sound). Examples of construction: Fort Schuyler, at Throgg's Neck, Long island. In Brooklyn: Church, State street, west of Bond street; church, Carroll street, south of Court street; church, Marcy avenue; naval hospital, near Harrison avenue; church, Fourth street, near Broadway; church, Kent street, east of Franklin avenue.

MARBLE.—Swanton, Vermont.

All the Swanton marbles have the excellencies and defects of those of Mallett's head—that is, they are hard and somewhat difficult to work, but take a proportionately fine polish, which they retain longer than softer stones. The mistake is frequently made of using these mottled, veined, and brecciated marbles for tiling, but this sort of wear speedily betrays the difference in hardness of the several parts and destroys their beauty; hence economy as well as good taste will be consulted by using for steps, thresholds, tiling, etc., the monochrome marbles only.—J. S. N.

Examples of construction. (See below.)

STATUARY MARBLE.—West Rutland, Vermont. Brilliant, white, somewhat tender and absorbent, and hence best fitted for use when it is not exposed to the weather. Similar marbles are also brought from Rutland Centre, Dorset, Danby, Pittsford, Brandon, Shelburne, and Middlebury, Vermont. Examples of construction. (See below.)

MARBLE.—Manchester, Vermont. A rather coarse, white stone, streaked or clouded with black or gray. Examples of construction: Building of Drexel & Morgan, corner of Wall street and Broadway, New York; Dutch Reformed church, corner of Twenty-ninth street and Fifth avenue.

MARBLE.—Sutherland Falls, Vermont.

General examples of construction in Vermont marbles: The Sutherland building, southeast corner of Sixty-third street and Madison avenue (beginning to be discolored by iron stains, chiefly derived from iron work); Savings Institution building on southeast corner of Clinton street and Atlantic avenue, Brooklyn. The latter building shows streaks of discoloration on moldings of cornices, etc.

WINOOSKI MARBLE.—Mallett's head, on Isle La Motte, in lake Champlain, near Burlington, Vermont.

It is mottled red, white, and brown, a hard stone, and somewhat difficult to work, but takes a high polish, and is very strong and durable. There is considerable variety in the tint of the Winooski marble, produced by the relative preponderance of the colors mentioned, and the size of the figure, some slabs being coarsely motled with white and brown, others chocolate and pale red, and others still light red, speckled, and mottled with white.—J. S. N.

Examples of construction: The reredos of Grace church, Broadway, between Tenth and Eleventh streets, New York.

MARBLE.—Isle La Motte, Vermont.

These marbles are dark gray and black; the latter is less deep in color than the Glens Falls and Lycoming black marbles, but is harder and stronger. It is largely used for tiling in combination with white marble or slate; for this purpose it has been in use for twenty-five years, proving itself to be an exceedingly durable and serviceable stone. The "fine gray" and "coarse gray" are valuable building stones.—J. S. N.

MARBLE.—Lee, Massachusetts.

The Lee marble is for the most part of a uniform though not brilliant white color, is coarser grained than the Vermont marbles, and yet finer than those of New York. It is a strong and durable stone, but contains a little iron, by the oxidization of which it becomes somewhat brown on exposure. It is doubtful whether its strength and durability are materially impaired by this, and the change of color which it produces is by some architects regarded as an excellence rather than a defect.—J. S. N.

It usually contains a little pyrites, but is a remarkably white marble. Example of construction: Saint Patrick's cathedral, Fifth avenue and Fiftieth street.

MARBLE.—West Stockbridge, Massachusetts.

It is similar in character to that from Lee, resembling coarse loaf-sugar.—J. S. N.

Examples of construction: The east, south, and west fronts of the old city hall, New York; the Treasury building in Wall street.

MARBLE.—Canaan, Connecticut.

It varies somewhat in color and texture, some of it being very white and of fine grain, and well adapted to monumental purposes; the greater part, however, is bluish-white or mottled. This is harder to work, more durable, and best suited for building.—J. S. N.

MARBLE.—Glens Falls, New York.

This is a very dark phase of the Trenton limestone. It has been little, if at all, metamorphosed, and is simply a hard limestone impregnated with carbonaceous matter, to which it owes its color. It is less hard and black than the most esteemed black marbles, but serves an excellent purpose for tiling, and is sometimes used for mantles and other interior decorations. Like all the black limestones, it will be found to lose its color and become gray by exposure to the weather.—J. S. N.

MARBLE.—Lockport, New York. (Already mentioned under Limestone.)

MARBLE.—Hastings, New York. Example of construction: The University building, University and Waverly places, often spoken of as "white granite".

MARBLE.—Tuckahoe, New York.

The quarries which furnish the Tuckahoe marble are located on one of the several belts of crystalline dolomite which traverse, with a north-northeast and south-southwest bearing, the country north of the city of New York. Of these, one reaches New York island, crossing the Harlem river at Kingsbridge; another outcrops on the sound, near New Rochelle; still others strike the Hudson above New York, at Hastings, Dobbs ferry, Sing Sing, etc. Several of these furnish good marble for building stone—gray, blue, or white—but none that is fine for decorative purposes. The best marbles yet obtained from these series of deposits are those of Tuckahoe and Pleasantville. The Tuckahoe marble is pure white in color, and much coarser in texture than any of those hitherto noticed. It is somewhat irregular in quality, but the better grades are highly esteemed for architectural purposes, and have been used in some of the finest buildings in the city of New York. * * * By exposure in the impure atmosphere of the city, its color changes to a light gray. This is apparently due to coarseness of texture, which gives a roughness to the surface and causes the smoke and dust to adhere to it more closely than they would to a finer stone.—J. S. N.

Examples of construction: The residence on the northwest corner of Thirty-fourth street and Fifth avenue; part of Saint Patrick's cathedral, Fiftieth street and Fifth avenue; the Stock Exchange building, and the New York Life Insurance building.

SNOWFLAKE MARBLE.—Pleasantville, Westchester county, New York.

The dolomite belt in which the Pleasantville marble quarries are situated is one of the broadest known, being more than half a mile in width. It consists chiefly of beds of impure dolomite, white or banded, which contain too much siliceous matter to be available for building or ornamental purposes, with some layers, often of considerable thickness, of pure white marble, in part similar to that of Tuckahoe, and partly still more coarsely crystallized. The beds are more or less interstratified with layers of granite and gneiss, the whole series standing nearly on edge among the marble layers in this locality; the most conspicuous and valuable is that which is worked by the Pleasantville Land Company, and which furnishes the "snowflake marble". This belt is about 400 feet wide, standing vertical, and consists throughout of pure white dolomite, almost without cloud or stain, and with no foreign matter.—J. S. N.

This stone weathers well in New York, but is apt to become stained, especially under window-sills. Examples of construction: The greater part of Saint Patrick's cathedral, New York; Union Dime Savings bank, Thirty-second street, between Sixth avenue and Broadway.

General examples of construction in Westchester marble: Block of houses on east side of Fifth avenue, between Fifty-seventh and Fifty-eighth street; the National Academy of Design, Fourth avenue and Twenty-third street; city hall, Brooklyn; court-house and municipal building; (?) Grand opera house, Eighth avenue and Twenty-third street; (?) church on northeast corner of Twenty first street and Fourth avenue; Stewart's store buildings, Broadway, between Chambers and Reade streets, and between Ninth and Tenth streets; many store buildings in Chambers, Warren, Murray, and Barclay streets, Park place, etc.; the United States hotel, corner of Fulton and Pearl streets.

MARBLE.—Williamsport, Lycoming county, Pennsylvania. The "ebony marble" from this locality is one of the most beautiful of American black marbles.

It is a jet-black stone, not quite equal to the Belgian black in purity of color and hardness, but it is very black, and takes a brilliant polish. It contains a few specks of pyrites, and here and there a hair-line ring of white, marking the section of a fossil; but it works with great exactness, and seems to be an excellent as it certainly is a handsome, stone.—J. S. N.

MARBLE.—Knoxville, Tennessee.

This is a highly-crystalline, compact, and hard marble, which varies in tint from brown to pink, but is not mottled, the color being distributed in sheets and belts, so that blocks of considerable size can be taken out, which are of nearly a uniform shade. Usually the color is pinkish-brown, traversed by lines of blue. It is free from cracks and flaws, and takes a very uniform and brilliant polish.—J. S. N.

Examples of construction: Ninth National Bank building; Park National Bank building; Grand Central hotel; Cisco building, etc.

MARBLE.—Doughertyville, Tennessee.

The prevailing tint of the Tennessee marble is chocolate, mottled with pure white, and is very pleasing to the eye. It is also commended by marble-workers as being sound and strong, and it takes, for a variegated marble, a high and uniform polish.—J. S. N.

MARBLE.—Carrara, Tuscany, Italy. Derived from the Jurassic, Trias, and Oolite.

The best quarries are opened along both sides of a deep valley, in which the village of Carrara is situated, and along which flows the Torano. In general the marble has a light bluish hue, or is white with bluish veins, such kinds being generally sawed into slabs at the numerous cutting and polishing mills situated along the course of the stream. The purer varieties, which are perfectly white, crystalline, and free from flaws, are quarried in blocks, sometimes 10, 12, or 14 feet in length, for statuary purposes, and drawn on strong wagons by teams of bullocks down to the railway station at Carrara.—Hull.

Its weight per cubic foot is 168.6 pounds. Examples of construction are abundant in mantels and interior decoration throughout our cities, and in the tombstones in Greenwood, Trinity, and Calvary cemeteries.

TRAP.—Palisades at Jersey City heights, Weehawken, etc., in Hudson county, New Jersey. Examples of construction: Stevens' institute, Hoboken, New Jersey, and the court-house and Saint Patrick's cathedral, Jersey City heights.

TRAP.—Graniteville, Staten island, New York. This is quarried almost entirely for pavements in the cities, and the refuse is crushed up to macadamize roads.

NORWOOD STONE.—Closter, New Jersey. Example of construction: Grace Episcopal church, One hundred and sixteenth street, near Third avenue.

SERPENTINE.—Hoboken, New Jersey. Examples of construction: Many private residences south of Stevens' hill; the wall facing part of the walk along the river; sewers and underpinnings, etc., throughout Hoboken.

SERPENTINE.—Chester, Pennsylvania. This stone is cheap and durable, and hardens by exposure.

This is a well-known coarse green building stone, quite largely used in Philadelphia and elsewhere. * * * It almost immediately assumes the appearance of age, which comports well with certain kinds of architectural design, and with the purposes of certain structures. It is also used in combination with other materials (brick and stone) with good effect, so that it adds an important element to the resources of our architects. The color is yellowish-green, it works with great facility, is fire-proof, and is probably durable.—J. S. N.

Examples of construction in serpentine and serpentine marble: Trimmings of synagogue on the southeast corner of Lexington avenue and Sixty-third street; arches in Saint Bartholomew's church, Madison avenue and Forty-fourth street.

B. PUBLIC BUILDINGS AND IMPROVEMENTS.

Many examples have been given of the common private edifices in whose construction the several varieties of building stone have been employed in this district, often, however, according to the caprice of owners and the hasty choice of architects. In the construction of many of the larger buildings, however, *e. g.*, asylums, hospitals, etc., the sunken portion of the Hudson railroad, as well as in the public edifices, more care and judgment seem to have been often exercised, and more interest is attached to the selection of materials in these cases.

1. PUBLIC BUILDINGS.—More or less reference has already been made to the materials used in the construction of the United States buildings, *e. g.*, the post-office, custom-house, barge-office, etc., and further details are given below of the character of construction in the fortifications of the bay and sound, in their approaches to the city.

It is sufficient to state in reference to other public buildings that their usual materials are given below, viz:

Prisons, bridges in parks and over the Harlem river—sandstone, limestone, granite, and gneiss.

The sewers—gneiss from the island and vicinity, and bowlders of a large variety of rocks derived from the excavations in glacial drift.

The Croton aqueduct, the high bridge over the Harlem river, and the reservoirs in the Central park and Prospect park, and at Forty-second street, New York city—granite from New England and gneiss from the island.

2. THE CENTRAL PARK.—In the report of the superintending engineer of the Central park for the year 1862 the following facts are given concerning the distribution of different building stones in the inclosing-walls, bridges, etc., within this park.

Freestone from Albert quarry, New Brunswick (also walls, etc., in Prospect park, Brooklyn); from Dorchester and Weston, New Brunswick, and from New Jersey—vertical wall and bridges.

Brown sandstones from base of Palisades, New Jersey—part of vertical wall.

Mountain graywacke and blue-stone from Hudson river, New York—part of vertical wall.

Limestone from Mott Haven and from Greenwich, Connecticut—part of vertical wall; granite from Radcliffe's island, Maine—bridges; gneiss, in park, bridges and retaining-wall, and lower portion of vertical wall; gneiss and white marble from Westchester county, New York—bridges.

3. FORTIFICATIONS.—Fort Richmond: granite from Dix island, Maine; fort Lafayette: brown sandstone (New Jersey); the fortifications at Willett's point: granite from Spruce Head, Maine; fort Schuyler (on Throgg's Neck): gneiss: fort Wadsworth, on Staten island, fort Hamilton, and fort Diamond are of Maine granite, as are also the defenses on Governor's, Bedloe's, and Ellis islands.

4. NEW YORK AND BROOKLYN BRIDGE.—I am indebted to Mr. F. Collingwood, the engineer in charge of the New York approach, for the following statistics, which have been compiled from his letters:

Materials used.—Granite, from the following localities: Frankfort, Maine; Concord, New Hampshire; Spruce Head, Maine; cape Ann, Massachusetts; Hurricane island, Maine; Westerly, Rhode Island; East Bluehill, Maine; Stony Creek, Connecticut; Mount Desert island, Maine, and Charlottesburg, New Jersey. Limestone, chiefly from Rondout and Kingston, New York; also, from Isle La Motte and Willsborough point, lake Champlain; and from near Catskill, New York.

Distribution.—In the anchorages the corner-stones, exterior of cornice and coping, and the stones resting on anchor plates consist of granite from Charlottesburg and Stony Creek, in the New York anchorage, and from Westerly, in the Brooklyn anchorage. The rest of the material is entirely limestone, partly from Rondout, largely from lake Champlain. In the towers limestone was chiefly employed below the water-line, and, above it, granite from all the localities named, except Charlottesburg, Westerly, and Stony Creek. In the approaches the materials were arranged in about the same way as in the towers.

Total quantities.—The amounts of granite and limestone employed are estimated in round numbers as follows:

	Cubic yards.	Authority.
Anchorages	10,000	F. Collingwood.
Towers	85,159	E. E. Farrington.
Approaches	21,000	F. Collingwood.

In addition to the hewn stone considerable quantities of rubble were employed from various sources, but largely from Greenwich, Connecticut.

Selection.—The reasons for selection were the following: first, soundness, in regard to durability, and freedom from iron; second, color; third, price, with reference also to facilities for prompt delivery. As a rule all the cornices, parapets, and other cross-cut work and band-courses were required to be light in color. The granite for these was largely from East Bluehill; also from Westerly, Stony Creek, etc. On the contrary, base stones and spandrel stones were required to be dark. For these granite from cape Ann, etc., was used. The limestone was employed partly for cheapness and partly on account of greater specific gravity, as weight was desirable at the base of the towers and in the anchorages.

Strength.—Tests were made at the bridge works by Mr. Probasco on a number of samples of stones, in blocks 2 inches square, or with about 4 square inches of surface, with the following results:

Kind of stone.	Locality.	Position.	Crushing weight per square inch.
Granite	Frankfort, Maine	On bed	18,026
Do	do	Not on bed	15,700
Do	Spruce Head, Maine	On bed	14,200 to 15,875
Do	East Bluehill, Maine	do	12,125 to 16,250
Do	Long Cove, Maine	do	14,040
Do	Concord, New Hampshire	do	17,550
Syenite	Cape Ann, Massachusetts	do	15,861 to 19,280
Do	do	Not on bed	17,875
Granite	Quincy, Massachusetts	On bed	18,000 to 19,600
Do	Millstone point, Connecticut	do	17,425 to 17,550
Sandstone	Medina	Not on bed	11,880
Bluestone	Hudson river	On bed	9,000 to 13,000
Do	do	Not on bed	11,482
Limestone	Kingston, New York	On bed	13,750 to 15,550

[These figures have been incorporated in Table II.]

5. ROOFS, PAVEMENTS, AND SIDEWALKS.—*Roofs.*—Slate is very largely used for most roofs having a steep pitch. Many varieties are used, which are mainly derived from the following localities: Purple and green—Poultney, Castleton, and Fairhaven, Vermont; red—Middle Granville, New York, and Slatington, Lynnport, Bethlehem, etc., Pennsylvania.

Pavements.—The streets of these cities are mainly paved with stone, many experiments having been made, particularly in New York, in reference to the selection both of the best material and most satisfactory shape. It is a well-known fact that Broadway tests pavements more severely perhaps than any other street in the world.

For cobble-stone pavement bowlders and large pebbles from the till of the island are employed. It is found that the pointed ends of the cobble-stones, lying downward, have a tendency to sink unequally under heavy pressure, and that consequently hollows form in the pavement, rendering the roadway impassable.

The Russ pavement was first laid about the year 1853. It becomes smooth and slippery by uninterrupted travel. It consists of large square granite blocks, sometimes grooved, and answers temporarily, but the grooves are found to wear smooth at their edges. An attempt to groove the blocks already laid down led to the discovery that—

> The surface of these stones had, by constant rubbing with iron horseshoes and wheel-tires, aided by atmospheric action, undergone such a physical (or chemical) change that the hardest steel tools could not cut the grooves, and the effort had to be abandoned. (*a*)

In order to increase the durability of the Russ pavement it was constructed in two layers in some portions of Broadway, the lower consisting of large, irregular, angular pieces of rock laid in the earth. Elsewhere large flag-stones were laid below, then a layer of earth, and then the large blocks of trap or granite. However, the result was unsatisfactory. The whole of the pavement has been broken up, and the blocks split into smaller cubical pieces for use in Belgian pavement elsewhere.

> The stones for these [Belgian] pavements are obtained across the Hudson, where the range of basaltic rocks overlying the new red sandstone, and forming the eastern boundary of the state of New Jersey, contains many quarries. The Palisades, one of the natural wonders of the neighborhood, is a perpendicular range of basalt rocks from 300 to 600 feet high, forming the western bank of our beautiful river for a distance of some 20 miles. They are, in fact, a series exposed by nature, and the quarrying is going on so extensively there that some papers have expressed the fear that these picturesque walls will be destroyed; but a simple calculation shows the mass of basalt to be so immense that it would require several thousand years of constant labor at the present rate to make any great change in the outline. There is paving stone enough there for all the streets of New York, Brooklyn, Williamsburg, Jersey City, Hoboken, Hudson City, in short of the future great metropolis, covering several hundred square miles, and yet leave enough of the Palisades to be about as much of a natural curiosity as they are now. (*b*)

Still later, in place of basalt, a very hard kind of granite has been substituted, from the highlands of the Hudson, cut in flat blocks 10 by 12 inches square and 4½ inches thick, set edgewise, with longest dimension across the line of travel. "The pavement when laid looks much like a brick wall composed of very large gray bricks." This form appears more satisfactory in use than any previously employed. This has been also laid down in Atlantic and Myrtle avenues, Brooklyn.

Wood, concrete, and asphalt have been also used, in various combinations, on many of the streets, but in New York with little success, on account of the heavy wear to which they have been exposed; in Brooklyn the results have been more satisfactory. An enormous amount of trap, however, has been crushed and broken for use in macadamizing, and is still so employed in the upper avenues of New York island and in many of the streets in the

a *Manufacturer and Builder*, 1869, I, 194. *b* The *Manufacturer and Builder*, 1869, I, 194; also 1874, VI, 157.

Twenty-third and Twenty-fourth wards; in many avenues and side-streets on the outskirts of Brooklyn, Jersey City, and Hoboken, and many of the streets and roads on Staten island. For this purpose the supply of material is inexhaustible.

Some idea of the quantity and cost of the stone and other materials that have been consumed in New York city for this object, may be deduced from the following estimate, made in 1874:

	Miles.	Cost per square yard
Macadam (Guidet improved)	22	$6 06
Granite (granite block on trap)	26	2 70
Trap-block	180	2 40
Wood	14	5 00
Cobble	83	58
Concrete, asphalt, etc	3	3 50
	328	

Sidewalks.—All the sidewalks of New York city are paved with stone, chiefly flag-stone, and this predominates in Brooklyn and the adjacent cities. The following materials are used for paving:

Bluestone or flagging, which is brought by water from the various points along the Hudson river, and by rail from the interior of the state, the Catskill mountains, and from Pennsylvania. The principal localities have been already mentioned among the building stones, under the heading of "Blue-stone". It is used both with its natural surfaces of cleavage, and, in the the larger blocks, with its surfaces planed by machinery.

Huge hewn slabs of several varieties of granite have been largely introduced into the pavements of large business streets, especially of Broadway, within a few years. Notwithstanding their roughly-dressed or picked surfaces, they are very objectionable on account of their slipperiness when wet or when covered with coatings of ice and slush.

Mica-slate, from Bolton, Connecticut, etc., was formerly used in considerable abundance, before the development of the quarries of blue flagging. It is a white, glistering, schistose rock, resisting well the weather and ordinary travel; but was mostly laid down in small blocks, whose edges and corners were first abraded or became broken by hard or long-continued wear, the material on the whole being too soft and slippery for this use. Examples of it may still be found in the following streets, though it is being fast taken up for replacement by blue flagging: Along West Nineteenth street, in La Fayette place, between Astor place and Great Jones street; along Clinton and Waverly places; in Liberty street, near Greenwich street, etc.

Gneiss, from Haddam, Connecticut, also, like the preceding, was considerably used in the early history of the city. It was laid down in small square stones, about 18 inches square, with a very rough surface, and was used both for pavement and for coping. Probably much of the gneiss from New York island and from Willett's point was once employed for this purpose.

Examples of these sidewalks may yet be found in several of the old and narrow streets below Pearl, *e. g.*, Pine street, etc.

The curbstones in New York and adjacent cities consist entirely of stone, chiefly flag-stone, but in part hewn blue-stone and granite, from the localities above mentioned.

An approximate idea of the prevailing market prices, chiefly in the year 1882, of the stones more commonly employed may be derived from the following table. The prices refer to the rough stone, per cubic foot, as delivered on the dock in New York city:

SANDSTONE.

Locality.	Color.	Price per ton.	Price per cubic foot.	Remarks.
Springfield, Massachusetts	Red and brown	$11 00		
Venice	Brown	25 00		
Portland, Middlesex county, Connecticut	do		$1 00 to $1 50	
Middletown, Connecticut	do		1 50	
Belleville, New Jersey	do	$1 00 to $1 75	1 00 to 1 50	
Newark, New Jersey	do		1 00 to 1 50	
Dorchester, New Brunswick	do	15 00	1 05 to 1 30	1874.
	Drab		1 00 to 1 10	
	Olive		1 00	
	Yellow		1 00 to 1 07	
Mary's Point, New Brunswick	Brown	15 00	90 to 1 10	
	Salmon	15 00		
	Olive	15 00		
Wood Point, New Brunswick	Brown	14 00	1 00 to 1 10	
	Red	12 00	1 05	
Wallace, Nova Scotia				
Kennetcook, New Brunswick	Brown		1 00	
	Olive	12 00		
	Blue	13 00		

SANDSTONE—Continued

Locality.	Color.	Price per ton.	Price per cubic foot.	Remarks.
Berlin Heights, Ohio	Buff or yellow		$0 60 to $1 00	To $1 20, 1874.
	White		1 00	
New Amherst, Ohio	No. 1 buff		95 to 1 05	To $1 20, 1874.
	No. 1 blue and light drab		80 to 95	
Cleveland, Ohio	White		90 to 1 00	
	Blue		1 00	
Independence, Ohio			1 10	
Buena Vista, Ohio			1 55	
Cincinnati, Ohio			1 00	
Berea, Ohio			1 00	Varied 85 cents to $1 15.
Carlisle, England	Red		1 00 to 1 10	
Corsehill, Scotland	do		1 00 to 1 05	

LIMESTONE.

Ellettsville, Indiana			$1 25	
Caen, France			1 50	
Bedford, Indiana			1 25	

MARBLE.

Westchester county, New York			$1 50	
Canaan, Connecticut			$1 55 to 1 70	1876.
Sutherland Falls, Vermont			1 25 to 1 75	

GRANITE.

Millstone point, Connecticut			$0 60	
Roxbury, Connecticut			$0 65 to 1 25	
Quincy, Massachusetts			2 00	
Westerly, Rhode Island			1 50	
Mount Waldo, Maine			60	
Clark's island, Maine			75	
Spruce Head, Maine			60	
Round Pond, Maine			1 50	For stones 20 feet and under.
Granite (hammered)		About $16 50	1 00 to 1 50	

GNEISS.

Foundation stone (rubble)			$0 08 to $0 10	
Building stone, per load			2 00 to 3 00	

BLUE-STONE AND FLAG-STONE.

Wilbur, Ulster county, New York	Bluestone		$0 70 to $1 50	For sills, lintels, etc.
	do		07 to 1 00	For copings (per yard).
Kingston, Ulster county, New York	do		09 to 3 50	
Smithville, Chenango county, New York	do		1 25	
Skinner's Eddy, Wyoming valley, Wyoming county, Pennsylvania	do		1 00 to 1 50	
Wyoming valley, Meshoppen, Wyoming county, Pennsylvania	do		1 50	

FLAG-STONE.*

Length in feet.	Thickness, inches.	Per square foot, cents.
3	2	3
4	2	4
5	2	3½
6	2	6½
8	4	10 to 12

*Pond Eddy, Lackawaxen, etc., Pike County, Pennsylvania; retailed at 15 cents to $1 50 per square foot.

ROOFING SLATE.

	Per square foot.
Purple or green	$7 00 to $8 00
Red	15 00
Black (Pennsylvania)	4 [illegible]

STATISTICS OF BUILDINGS (NUMBERS AND MATERIALS) IN NEW YORK CITY AND BROOKLYN.

Material.	NEW YORK CITY.				BROOKLYN.			
	District of wholesale business houses.	District of small stores and tenements.	District of large stores and residences.	Entire city.	District of warehouses, tenements, etc.	District of residences and small stores.	District of small residences, Long Island city.	Entire city.
Freestone:								
Brown sandstone	566	1,598	6,979	9,143	225	6,377	4	6,606
Nova Scotia sandstone	237	88	725	1,050	.....	167	.....	167
Ohio sandstone	.....	47	139	186	.....	.....	.....	.....
Foreign sandstone	.....	.....	13	13	.....	.....	.....	.....
Artificial	.....	.....	.....	.....	.....	.....	10	10
Limestone	.....	.....	3	3	1	1	.....	2
Bluestone	.....	.....	5	5	.....	.....	.....	.....
Granite	149	9	46	204	.....	3	.....	3
Gneiss	3	40	61	104	.....	18	5	23
Marble	636	10	272	918	7	87	.....	94
Brick	8,515	20,457	34,157	63,129	5,691	23,581	211	29,483
Stucco	5	23	166	194	51	587	.....	638
Iron	356	85	469	910	3	67	.....	70
Frame	590	10,360	13,384	24,334	3,926	33,556	948	38,430
Total	11,057	32,717	56,419	100,193	9,904	64,444	1,178	75,526
Buildings with stone fronts	.....	.....	.....	11,574	.....	.....	.....	6,880
Buildings constructed almost entirely of stone	.....	.....	.....	52	.....	.....	.....	25
Total stone	1,591	1,792	8,243	11,626	233	6,653	19	6,905
Total brick and stucco	8,520	20,480	34,323	63,323	5,742	24,168	211	30,121

STATISTICS OF BUILDINGS (NUMBERS AND MATERIALS) IN THE SUBURBS AND IN THE ENTIRE METROPOLIS.

Material.	STATEN ISLAND.	JERSEY CITY.			HOBOKEN.				New York city and its suburbs.
	Castleton, etc. (Staten island).	Jersey City proper, including Hudson City and Bergen city.	Bayonne and Greenville.	Entire city.	Hoboken proper.	West Hoboken and town of Union.	Weehawken.	Entire city.	
Freestone:									
Brown sandstone	8	294	38	332	121	21	.....	142	16,231
Nova Scotia sandstone	3	4	.....	4	7	.....	.....	7	1,231
Ohio sandstone	.....	15	.....	15	.....	.....	.....	.....	201
Foreign	.....	.....	.....	.....	.....	.....	.....	.....	13
Artificial stone	.....	.....	.....	.....	.....	.....	.....	.....	10
Limestone	.....	.....	.....	.....	.....	.....	.....	.....	10
Bluestone	.....	.....	.....	.....	.....	.....	.....	.....	215
Granite	4	4	.....	4	.....	.....	.....	.....	153
Gneiss	15	3	.....	3	7	1	.....	8	1,027
Marble	12	3	.....	3	.....	.....	.....	.....	63
Trap	.....	8	50	58	.....	5	.....	5	.....
Brick	716	4,441	224	4,665	1,708	174	31	1,913	99,906
Stucco	16	96	.....	96	136	5	.....	141	1,085
Iron	.....	8	.....	8	.....	.....	.....	.....	988
Frame	6,951	12,656	3,036	15,692	1,518	2,452	98	4,068	89,475
Total	7,725	17,532	3,348	20,880	3,497	2,658	129	6,284	210,608
Buildings with stone fronts	40	331	88	419	135	27	.....	162	19,075
Entirely of stone	2	.....	.....	.....	.....	.....	.....	.....	79
Total stone	42	331	88	419	135	27	.....	162	19,154
Total brick and stucco	732	4,537	224	4,761	1,844	179	31	2,054	100,991

STATISTICS CONCERNING THE PHYSICAL PROPERTIES OF THE BUILDING STONES USED IN NEW YORK CITY.

GRANITE.

Kind.	Locality.	Size of cube in inches.	Position.	Number of trials.	Compressive strength per square inch: Range	Compressive strength per square inch: Average.
					Pounds.	*Pounds.*
Red	Bay of Fundy, Canada	2	Bed	2	11,812 to 12,020	11,916
Do	do	2	Bed	1		17,500
Do	do	2	Edge	1		18,750
Do	Fox island, Maine	2		2	11,700 to 14,875	13,287
Do	do	2	Bed	1		15,062
Do	do				11,892 to 14,185	
Do	Dix island, Maine	2		1		15,000
Do	do					24,000
Do	Spruce Head, Maine	2		2	13,500 to 17,500	15,500
Do	do	2	Bed		14,200 to 15,875	
Gray	Hurricane island, Maine	2	Bed	2	11,000 to 14,425	12,712
		2	Edge	1		14,937
Do	Palmer quarry, Maine					
Do	Jonesboro', Maine				11,233 to 15,952	
Light	Harbor quarry, Maine	2	Bed	2	16,218 to 16,837	16,527
Do	East Bluehill, Morgan's bay, Maine	2				17,200
Do	East Bluehill, Maine	2	Bed		12,125 to 16,250	
Light gray	East Boston, Maine	2	Bed	2	16,031 to 18,000	17,015
Do	City Point, Maine					
Do	Frankfort, Maine	2	Bed	1		18,026
		2	Edge	1		15,700
Do	Carver's quarry, Maine					
Do	Long Cove, Maine	2	Bed	1		14,040
Do	Wharf quarry, Maine					
Do	K., W. & Co.'s quarry, Maine					
Do	Concord, New Hampshire				8,812 to 9,838	
Do	do	2	Bed	1		17,550
Dark	Quincy, Massachusetts	2				17,750
Do	do	2	Bed		18,000 to 19,600	
Do	do					9,739
Do	do				11,730 to 15,622	
Light	do	2				14,750
Gray or mottled	do	2.2 to 2.9		2	12,390 to 15,929	
Do	Quincy, Massachusetts (Wigwam quarry)	1.5		3		29,330
Do	Cape Ann, Massachusetts	2	Bed	2	12,423 to 19,500	15,961
Syenite	do	2	Bed		12,861 to 19,280	
		2	Edge			17,875
Gray	Rockport, Massachusetts	2	Bed	1		16,300
		2	Edge	1		19,750
Do	do					15,296
Old quarry	Westerly, Rhode Island	2		2	17,250 to 17,750	17,500
Gray	do	2	Bed	1		14,687
		2	Edge	1		14,927
Do	do				15,591 to 18,778	
Do	Millstone point, Connecticut	2		2	16,187 to 18,750	17,468
Do	do	2	Bed		17,425 to 17,550	
Do	Greenwich, Connecticut	2		2	11,300 to 11,700	11,500
Do	Plymouth, Connecticut				8,620 to 10,412	
Niantic river	New London, Connecticut	2		1		12,500
		2	Edge	1		14,175
Porter's rock	Mystic River, Connecticut	2	Bed	1		18,125
		2	Edge	1		22,250
Gray	Stony Creek, Connecticut	2	Bed	2	15,000 to 15,750	15,375
		2	Edge	1		16,750
Do	Tarrytown, New York	2	Bed	1		18,250
Flagging	Hudson river, New York	2		1		13,425
Gray	Garrison's, Hudson river, New York	2	Bed	1		12,260
		2	Edge	1		13,370
Do	Peterhead, Scotland*	1.5			8,290 to 18,636	
Do	do*	1				6,273
Do	do*				9,666 to 10,192	

* Foreign stones for comparison.

STATISTICS CONCERNING THE PHYSICAL PROPERTIES OF THE BUILDING STONES USED IN NEW YORK CITY.

GRANITE.

Specific gravity.	Weight of one cubic foot.	Ratio of absorption.	Remarks.	Transverse strain.	Authority.
	Pounds.			*Pounds.*	
2.600	162.5	Not noticeable	Boldly marked, resembling fine breccia		Q. A. Gillmore.
		do	do		Do.
			Used in Central park		
2.631 to 2.660	164.1 to 166.3	Very slow	Burst suddenly		Do.
2.660	166.3	do	do		Do.
					C. B. Richards.
2.635	166.5	Very slow	Burst suddenly		Q. A. Gillmore.
2.750	171.9	Very slow	Burst suddenly		Q. A. Gillmore.
					Probasco.
2.670	166.9		Burst suddenly		Q. A. Gillmore.
					C. B. Richards.
2.650	165.6	Not noticeable	Boldly marked, resembling fine breccia		Q. A. Gillmore.
	166.5	0.233 per cent			J. S. Newberry.
					Probasco.
2.630	164.4	Not noticeable	Finely marked; bluish		Q. A. Gillmore.
					Probasco.
					Do
					Probasco.
					C. B. Richards.
					Probasco.
2.660	166.2	Very slow	Cracked before bursting		Q. A. Gillmore.
					Probasco.
2.67				235	T. Rodman.
					C. B. Richards.
2.695	168.7	Very slow	Cracked before bursting		Q. A. Gillmore.
					W. R. Johnson.
2.649 to 2.657	165.8	3.25 grains			Do.
		do	Broke suddenly		Do
					Probasco.
2.610	163.2	1 to 152			Q. A. Gillmore.
2.65				274	T. Rodman.
2.646	165.6	Very slow	Broke suddenly		Q. A. Gillmore.
2.670	166.9	do	do		Do.
					C. B. Richards.
2.706	168.7	Very slow	Broke suddenly		Q. A. Gillmore.
					Probasco.
2.835	177.2	Very slow	Broke suddenly		Q. A. Gillmore.
					C. B. Richards.
2.660	166.25	Very slow	Broke suddenly		Q. A. Gillmore.
2.630	164.4	do	do		Do.
2.645	165.4	1 to 201	Burst suddenly		Do.
2.655	162.2	Very slow	Cracked before bursting		Do.
2.690	168.1	do	Broke suddenly		Do.
2.580	161.3	1 to 167			Do.
					G. Rennie.
		0.5 to 3.0 per cent	Wray		V.
					Bramah.

STATISTICS CONCERNING THE PHYSICAL PROPERTIES OF THE BUILDING STONES USED IN NEW YORK CITY—Continued

GNEISS

Kind.	Locality.	Size of cube in inches.	Position.	Number of trials	Compressive strength per square inch: Range.	Compressive strength per square inch: Average.
					Pounds.	*Pounds.*
Harlem stone	Morrisania, New York	2		1		15,800
Dark	Madison avenue, New York	2	Bed	1		11,250
		2	Edge	1		12,500

TRAP.

Blue	Staten Island, New York	2	Bed	1		22,250
Very dark	Jersey City heights, New Jersey	2	Bed	2	20,750 to 22,250	
Do	Palisades, New Jersey					19,500
Whetstone	England*					8,267
Do	do*					11,970

MARBLE.

Eastchester	Tuckahoe, New York	2	Bed	2	12,050 to 12,950	12,500
Do	do	2	Bed	2	13,594 to 13,711	13,652
Do		4		1		4,081
Do		1.5	Bed	1		23,917
Do	Hastings, New York	1.5	Bed	9		18,941
Do	Pleasantville, New York				18,000 to 24,000	
Vermont	Dorset, Vermont	2	Bed	1		7,612
Do	do	2	Edge	1		8,670
Do	Rutland, Vermont				1,305 to 1,375	
Do	West Rutland, Vermont				11,000 to 12,500	
Do	Pittsford, Vermont				11,250 to 18,750	
Do	Sutherland Falls, Vermont				10,243 to 11,250	
Do	do				12,250 to 20,000	
Do	West Stockbridge, Massachusetts	1.5	Bed	4		10,382
Do	do	1.5	Bed	12		9,071
Do	Stockbridge, Massachusetts	1.5	Bed	10		8,812
Do	Lenox, Massachusetts	1.5	Bed	8		7,153
Do	Stockbridge, Massachusetts	4		1		2,410
Do	Lee, Massachusetts	1.5	Bed	3		22,702
White	do				12,917 to 13,972	
Bluish	do				7,705 to 17,954	
Do	Canaan, Connecticut				4,958 to 8,794	
Carrara	Carrara, Italy*				9,723 to 12,600	
Common Italian	Italy*	2	Bed	2	12,250 to 13,062	12,156
White Italian	do*	1.5				21,778

SANDSTONE.

Freestone	Dorchester, New Brunswick	2	Bed	2	9,150 to 9,412	9,281
Freestone (olive)	do	2	Bed	1		4,250
		2	Edge	1		6,050
Freestone (brown)	Mary's Point, New Brunswick					9,250
Freestone (olive)	do					9,250
Freestone (dark brown)	do				7,586 to 7,828	
Freestone	Wood Point, New Brunswick				3,976 to 4,932	
Do	Nova Scotia				6,532 to 10,322	
Brownstone	Middletown, Connecticut	2	Bed	1		6,950
		2	Edge	1		5,550
Do	Portland, Connecticut				5,806 to 10,928	
Do	San Diego, California*					20,039
Carlisle stone	Corsehill, Scotland*	6				7,309
Do	Craigleith, Scotland*	1				3,157
Do	do*	1.5				5,489
Do	do*	2				7,842
Brown	Little Falls, New York	2	Bed	1		9,850
		2	Edge	1		9,150
Red	Haverstraw, New York	2	Bed	1		4,350
		2	Edge	1		4,025

* Foreign rocks for comparison.

STATISTICS CONCERNING THE PHYSICAL PROPERTIES OF THE BUILDING STONES USED IN NEW YORK CITY—Continued.

GNEISS.

Specific gravity.	Weight of one cubic foot.	Ratio of absorption.	Remarks.	Transverse strain.	Authority.
	Pounds.			*Pounds.*	
2.720	170.0	Very slight	Broke suddenly		Q. A. Gillmore.
2.920	182.5		Probably rich in iron		

TRAP.

2.861	178.8	Very slight	Cracked before bursting		
3.030	189.5	Not noticeable			
			For pavements		
			Basalt (?)		Bramgh
		Trace	do		Fairbairn

MARBLE.

2.875	179.7	Very small	Burst without cracking		Q. A. Gillmore.
2.800	175.0		Burst without cracking; whiter and better variety		Do.
					Page.
2.858	178.6	0.00393 oz			United States Commission, 1851.
2.861	178.8	0.0066 oz			Do.
					Q. A. Gillmore.
2.635	164.7	1 to 170	With slight explosion		Do.
2.683	167.8		do		Do.
2.635					H. A. Cutting.
2.666	167.0				United States Government.
2.661 to 2.672					H. A. Cutting.
					F. E. Kidder.
	166–178				United States Government.
2.714	169.6	0.0068 oz			United States Commission, 1851.
2.713	169.6	0.007025 oz			Do.
2.713	169.6	0.0087 oz			Do.
2.709	169.3	0.011966 oz			Do.
					Page.
2.862	178.9	0.0103 oz			United States Commission, 1851.
					Do.
					C. B. Richards.
					Do.
2.69	168.2	Very small	Without cracking		Q. A. Gillmore.
		Trace			Rennie.

SANDSTONE.

			Without cracking		Q. A. Gillmore.
			do		Do.
			do		Do.
					J. Henry.
					Do.
					C. B. Richards.
2.360	148.5	1-40	Without cracking		Q. A. Gillmore.
					C. B. Richards.
2.640				425	T. Rodman.
					Kirkaldy.
					V.
					G. Rennie.
		8 per cent			Royal Commission.
2.250	140.6	1 to 34	Suddenly hardened by weathering		Q. A. Gillmore.
2.130	133.1	1 to 23	Without cracking		Do.

STATISTICS CONCERNING THE PHYSICAL PROPERTIES OF THE BUILDING STONES USED IN NEW YORK CITY—Continued.

SANDSTONE—Continued

Kind.	Locality.	Size of cube in inches	Position	Number of trials.	Compressive strength per square inch: Range.	Compressive strength per square inch: Average.
					Pounds.	*Pounds.*
Gray	Belleville, New Jersey	2	Bed	1		11,700
		2	Edge	1		10,250
Pink	Medina, New York	2	Bed	1		17,250
		2	Edge	1		14,812
Drab	do	2	Bed	1		17,725
Do	do	2	Edge	1		11,880
Do	Berea, Ohio	2	Bed	5	29,000 to 41,000	
Brownish-gray	North Amherst, Ohio	2	Bed	2	5,775 to 6,650	6,212
		2	Edge	1		5,450
Light drab	do				7,000 to 8,000	
Do	Cleveland, Ohio				6,141 to 8,955	
Do	Berlin, Ohio	2	Bed			14,250
		2	Edge			12,000
Reddish brown	East Longmeadow, Massachusetts				9,121 to 13,506	
Brown	do				8,062 to 8,812	
Do	do				13,520 to 14,650	

SANDSTONE (BLUE-STONE)

Blue-stone	Hudson river, New York	2	Bed		9,000 to 13,000	
		2	Edge			11,482
Do	Ulster county, New York				21,150 to 23,825	
Graywacke	Penmenmawr, Wales*	2				16,893

LIMESTONE.

Glens Falls	Glens Falls, New York	2	Bed	1		11,475
		2	Edge	1		10,750
Lake	Lake Champlain	2	Bed	1		25,000
		2	Edge	1		21,500
North river	Kingston, New York	2	Bed	1		13,900
		2	Edge	1		11,050
Do	do	2	Bed		13,750 to 15,550	
Do	Garrison's station, New York	2	Bed	10		18,500
		2	Edge	1		18,275
Do	do	2	Bed	3	17,750 to 18,775	18,262
Caen	Caen, France*	2	Bed	2	3,450 to 3,650	3,550

*Foreign rocks for comparison.

STATISTICS CONCERNING THE PHYSICAL PROPERTIES OF THE BUILDING STONES USED IN NEW YORK CITY—Continued.

SANDSTONE—Continued.

Specific gravity.	Weight of one cubic foot.	Ratio of absorption.	Remarks.	Transverse strain.	Authority.
	Pounds.			*Pounds.*	
2.259	141.0	1 to 27	Suddenly		Q. A. Gillmore.
2.410	150.6	1 to 55	Lilac		Do.
2.390	149.3	1 to 51	More purple		Do.
2.420	151.1	1 to 70			Do.
					Probasco.
2.110 to 2.200	131.9 to 137.5	1.16 to 1.24	Without cracking; very friable		Q. A. Gillmore.
2.16 to 2.19	135.0 to 136.9	1 to 19	do		Do.
2.14	133.7		do		Do.
					J. S. Newberry.
					C. B. Richards.
					Q. A Gillmore.
					Do.
					Saulsbury.
					McGregory.

SANDSTONE (BLUE-STONE).

					Probasco.
					Do.
2.720				609	T. Rodman.
					Fairbairn.

LIMESTONE.

2.700	168.8		Burst without cracking		Q. A. Gillmore.
2.750	171.9		do		Do.
2.69	168.2		do		Do.
					Probasco.
2.635	164.7		Burst without cracking		Q. A. Gillmore.
2.616	163.5		do		Do.
1.900	118.8	1 to 19 9.86	Burst without cracking; tensile strength, 150 (G. R. Bunnell); loss in dilute acid and boiling water, 6.17 per cent.		Do.

NORTH ADAMS, MASSACHUSETTS.

The materials used in the principal stone structures of this city are limestone from North Adams and quartzite from Clarksburg, Massachusetts. The foundations and underpinnings are of local limestone and Clarksburg quartzite, with some blue-stone. The Catholic church and two factories are built of limestone from the local quarries. Dr. Babbits' residence and Mr. Pendeman's office are two small edifices built of quartzite; as this contains a little pyrites some of the blocks are stained. The new Episcopal church in course of construction will be of blue-stone and pressed brick, with Longmeadow and Ohio sandstone trimmings over the windows and doors. The steps to the chancel will be of marble and the interior trimmings over the windows of terra-cotta. The railroad depot buildings and most of the churches are built of brick. The Hoosac tunnel is at this place, but the material used for archways is brick. The streets are paved with stone, the chief part of such pavement being on Eagle street, where cobble-stones are used for the purpose. The sidewalk on one block in front of the Wilson house is paved with North River blue-stone. Many of the sidewalks are paved with concrete; the curbs are of blue-stone, limestone, and quartzite.

NORTHAMPTON, MASSACHUSETTS.

There are but two buildings in Northampton entirely constructed of stone, and there are two others with stone fronts. The material used for the better class of stone construction is sandstone from Longmeadow, Massachusetts, and brownstone from Portland, Connecticut. One of the Congregational churches is built of the former material and the Smith Charities building of the latter. The materials used for foundations and underpinnings are sandstone and granite from quarries within the limits of the town, as both these formations are here exposed. One or two hundred feet of the pavement in front of the court-house is of thinly bedded sandstone from Smith's ferry; these blocks frequently exhibit rows of "bird tracks" upon them. They are now very much worn and the tracks are becoming obliterated. There is a quarry of coarse sandstone very near the Mount Tom station, 3 miles south of the main village, which furnishes stone for ordinary puposes of construction in the neighborhood. The streets are not paved with stone, with the exception of the space fronting the court-house already mentioned, and the sidewalk pavement is mostly of asphalt and brick; curbstones are of granite. The piers of the bridge across the Connecticut river are of sandstone from neighboring quarries.

OGDENSBURG, NEW YORK.

Limestone from the quarries near this city is of good quality, blue-black in color; and there are some examples of excellent stone work built of it, including range work and ashlar. Some of the structures of this limestone have Potsdam sandstone trimmings. These two materials when used together make a good harmony of colors, and the effect is pleasing. In some portions of these quarries it is necessary to use care in selecting the material, as parts of it contain iron. Some of the Ohio sandstones in the structures here have discolored, while others have retained their original appearance. There are several stone grist-mills in the city, two of the number being trimmed with sandstone from Potsdam and Hammond, Saint Lawrence county; the others are trimmed with native limestone. There are some heavy bridge abutments all constructed of limestone from the quarries within the city limits, and the breakwater is constructed of the same material. The streets and roadways are macadamized with limestone from the local quarries, and a few are paved with Potsdam sandstone; but few of the sidewalks are paved with stone, and the material used is the Potsdam sandstone. The curbstones are of Potsdam stone and limestone from Chaumont.

ORANGE, NEW JERSEY.

The cities of South and East Orange may be said to be noted for the size and elegance of their church edifices. They are all substantial buildings; several of them are brick with sandstone trimmings. Sandstone is largely used in cemetery walls, in walls surrounding lawns and other inclosures, in steps, house-trimmings, and in cellars and foundations. Nearly all of it has been obtained from the quarries in the faces of First mountain, 2 miles west of the town of Orange. The durability of the stone has been tested in the First Presbyterian church, erected in 1813, and also in some of the old walls in farm-houses of the surrounding country. The town is also noted for its Telford or macadamized roadways, in common with all of Essex county. Many miles of the best roads found in the United States are in this county; they are made of trap-rock from the large quarries in the eastern face of Orange or First mountain, a few miles west of Orange, which are all under the management of the Essex Road board. (*a*)

The following is a list of prominent stone structures in Orange, with materials from which they were constructed: Saint Mark's P. E. church, Grace P. E. church, First Presbyterian church, Central Presbyterian church, Munn Avenue church, South Orange Presbyterian church, all of Orange sandstone; South Orange P. E. church, trap-

a See Annual Report of the State Geologist of New Jersey, 1871.

rock with sandstone trimmings, both from local quarries; Orange Valley Congregational church, trap-rock with sandstone trimmings; South Orange Baptist church, Ohio sandstone; Saint Mark's P. E. church and school, Mr. J. G. Barker's residence, Mr. Davis Collamore's house, and Mr. Tome's private residence, all of trap-rock and sandstone, from local quarries.

There is no stone street pavement, excepting the road-bed of the First Street horse-car road, a road which is paved partly with rectangular blocks of trap-rock and partly with cobble-stones. The streets and roadways are pretty generally macadamized with trap-rock. The sidewalks are largely paved with stone, and the material used for this purpose is the North River blue-stone, from Ulster county, New York. Curbs are of the same material.

OSWEGO, NEW YORK.

The Oswego gray sandstone quarried in the vicinity is a good building material, except when set on edge in the exterior walls of buildings, in which case it flakes off by the action of dampness and frost. It is not suitable for sidewalk paving because its laminated structure causes it to separate into thin layers, when it easily breaks up under the action of foot-wear. Limestone from Chaumont, Jefferson county, New York, was used in the piers and abutments of the highway and railway bridges crossing the Oswego river in this city; it was also the principal stone used in the two dams across this river. A portion of the old breakwater now being destroyed consists of cut limestone from Chaumont. Fort Ontario—principally an earthwork—has some stone bastions of Oswego gray sandstone, and the largest and best quarry in this city is located in the fort grounds. The stone filling in the new breakwater cribs consists mostly of hardhead cobbles, with some quarried gray sandstone. Some red sandstone, found along the Oswego river about a mile south of its mouth, was used for crib-filling, but, owing to its rapid disintegration by wave action, it is no longer used for that purpose. For foundations and underpinnings the Oswego gray sandstone quarried in the immediate vicinity and some Chaumont limestone were used. There are but three streets paved with stone, and those chiefly with cobble. About half a mile of the 2 miles of paved street consists of block stone of materials from Potsdam, Jefferson county, North River blue-stone from Ulster county, and Oswego sandstone. The sidewalks are but little paved with stone, and the material used is Cayuga Lake stone, with some also from Chenango and Delaware counties. The curbstones are of Chenango County sandstone and Chaumont limestone.

PATERSON, NEW JERSEY.

There are sandstone quarries in the First mountain, near Paterson, which furnish a large part of the material for stone construction in the city. This sandstone is used largely in cellar walls and foundations; the quarries are in the eastern face of the mountain within the city limits and above the general level of the city, so that stone is afforded at a low rate. A quarry at Haledon, about 3 miles to the northwest, has furnished some material during the past season; this is a buff-colored Triassic sandstone resembling the Ohio sandstone. Within the city limits there are several old farm-houses, or structures originally built for farmers' houses, of red sandstone; the durability of the material as shown in these buildings is evidence of the value and adaptation to use in stone construction. Some of them were probably built of surface rock, that is, of loose blocks found on the surface in clearing up the country for farming purposes. In the adjacent parts of Passaic county there are very many old houses built of the native sandstone. These houses are usually low, being only a story and a half in height. The stone in the walls is sometimes dressed with square edges, and in some instances it is laid up rough-dressed only; and much of it is coarse-grained and soft.

The brown freestone of the Paterson and Little Falls quarries has been used extensively in the city, and there are many large structures of the material, among which may be mentioned the Passaic County court-house and jail, and the Roman Catholic church. This material has also been used in the construction of the aqueduct of the Water-Power Company, in the bridges over the canal, and in abutments and piers of bridges crossing the Passaic river; also largely in walls inclosing lawns and private grounds. The number of miles of graded streets in Paterson is 53; of this length 2.76 miles are paved with cobble-stones; 0.16 mile with macadamized block pavement, the material being brought from New England; 9.44 miles with macadamized Telford pavement; the total number of miles of paved streets, 12.36. The sidewalks are largely paved with stone, there being about 25 miles of stone sidewalks, and the material used for this purpose is the North River blue-stone, with some stone from Carr's, Sussex county. The curbs are of North River blue-stone.

PAWTUCKET, RHODE ISLAND.

The five stone buildings in Pawtucket are constructed of what is known as the ledge stone, which is quarried in the vicinity. Foundations and underpinnings are of blue and red slate from ledges in the town, and bowlders gathered in the vicinity. Some of the underpinnings are of granite from Smithfield and Diamond Hill. All the mills, excepting two or three, are of brick or wood. There is one large mill made of ledge stone and bowlders in the vicinity. There are ledges of slate from which material is obtained for walls, underpinnings, etc., and

bowlders are somewhat used for the same purposes. The two materials most used beside brick, for post trimmings and sills and underpinnings in the better houses, are granites from Smithfield and from Diamond Hill. The post-office front is partially of yellow sandstone, and the remainder is of brick with red sandstone trimmings, and several polished columns of red Aberdeen granite which resembles very much the material from Jonesboro', Maine. There are two stone bridges in the city; the upper one, built in 1858, has two arches of granite from a quarry in North Providence, near Smithfield. The Division Street bridge is a fine granite structure of 9 arches, and is built of granite quarried at Sterling, Connecticut. Only the streets in the central portion of the town are paved, and those chiefly with cobble-stones, though in recent years granite blocks of material from Diamond Hill have been employed. The sidewalk paving is chiefly of brick and concrete, though Hudson River flags and granite have been employed to a limited extent for this purpose. The curbstones are of granite from Diamond Hill and Smithfield, with some Hudson River blue-stone.

PETERSBURG, VIRGINIA.

There are three stone buildings in Petersburg—one, the custom-house, built of granite from the Namozine district, Dinwiddie county, in the immediate vicinity of the city. It is now more than twenty years since it was completed, and the stone is remarkably free from discoloration of every kind. That in the foundation, from the quarry of Dr. E. W. Lassiter, ranks with the best of building stones; and that in the superstructure is from a quarry now abandoned. The two fronts of Connecticut sandstone, on Sycamore street, show signs of decay; the material is destructible even in this latitude. The materials for foundations and all other ordinary purposes are obtained from the granite quarries in the immediate vicinity. A few of the streets are paved with cobble-stone; there is very little sidewalk paving of granite from the local quarries, and North River blue-stone, from Rondout, New York, has also been used for paving. Curbstones are of local granite.

PHILADELPHIA, PENNSYLVANIA.

That stone began to be an important element in construction in Philadelphia from its first settlement, and that it has always been preferred to other materials for use in the better class of buildings, we learn from old records that occasionally refer to the subject, and from the evidence of stone structures of various dates still standing. Many of the first brick houses with stone foundations are still standing in the older parts of the city, and may be known by their quaint style of architecture and by the peculiar checkered appearance of their walls, which are built of red and glazed bricks, arranged alternately—as the Penn mansion in Letitia court, built in 1682; the Swedes' church, in 1698, and Carpenter's hall, in 1770.

Government buildings, and college, school, church, hospital, prison, and most other public buildings are of stone, which has always held the first rank in the construction of the private residences of the wealthier classes. Stone is also used to a more than ordinary extent for caps, sills, base courses, corners, and other trimmings of brick buildings. One of the most noticeable features of the city, and one which adds much to its appearance of uniformity, is due to the custom which has long reigned here of trimming brick buildings with plain marble caps and sills. Of late years, however, the custom has not been so rigid, as Connecticut brownstone, Amherst (Ohio) stone, Hummelstown (Pennsylvania) brownstone, and North River blue-stone have been extensively used for trimmings.

A record in the office of revision of taxes in Philadelphia gives the following statistics: Total number of buildings in city in 1880, 168,176; number of stone buildings in city in 1880, 10,518; percentage of stone buildings, 6.

Of the 10,518 buildings classed as stone it is estimated that about 6,000 are constructed entirely of stone, and that the remaining 4,518 have stone fronts.

Until within the last fifty years the rock formations in and near the city had furnished very nearly all the stone used for building purposes; within that time Connecticut brownstone, North River blue-stone, New England granite, Vermont and Massachusetts marbles, Ohio sandstone, Chester county, Pennsylvania, serpentine or greenstone, Hummelstown brownstone, Richmond granite, and other stones have been introduced and extensively used for the better class of buildings.

The southern portion of Philadelphia is built on an alluvial deposit of gravel and clay which furnishes nothing for building purposes except the smooth, rounded pebbles gathered on the banks of the Delaware, and which have been extensively applied to street paving—two thirds, perhaps, of the pavements in the city being of this material.

Near the central part of the city, the southern gneissic district, described by Professor Henry D. Rogers, (*a*) sets in. Of the area (129 square miles), including within the present limits of the city all not included in the alluvial deposit before described, excepting a few isolated exposures of steatite and serpentine, is made of this gneissic formation, and the ground where it prevails is gently rolling and sometimes hilly in its features. The process of grading and leveling has been going on to such an extent, especially in the more thickly settled parts of the city, that much of this rolling ground has been much modified in appearance. West Philadelphia, Fairmount park, Germantown, Manayunk, and other suburbs still retain something of their original features of surface.

a Vol. I, *First Geological Survey of Pennsylvania.*

Near the Fairmount water-works cliffs of the gneiss are exposed to view, the large reservoir being in fact built on a natural elevation of this stone, and most of the masonry in connection with the water-works is of the same material.

Professor Rogers, in the report before mentioned, describes the gneiss substantially as follows: There are three principal varieties. The most common and typical variety is a gray-bluish rather finely laminated triple mixture of quartz, feldspar, and mica, the quartz for the most part white or transparent, the feldspar usually white and very generally somewhat chalky from incipient decomposition, and the mica black or dark brown and in small plates. The next most common variety is a dark bluish-gray, sometimes grayish-black, gneiss composed of hornblende and quartz with sometimes a little feldspar, the hornblende greatly predominating. A third variety is a micaceous quartzose rock generally of a light gray color. Some beds of this variety contain such a predominance of the crystalline quartz in minute granular division, and such a subordinate quantity of mica disseminated through it, as to give it the character of ordinary gray whetstone.

These three varieties of gneiss, thus described by Professor Rogers, are found in inexhaustible quantities within and near the limits of the city, and have been its principal resource for the ruder and plainer purposes of construction. It has been freely used in foundations, cellars, inclosure and terrace walls, bridge abutments, piers, wharves, rubble pavements, and work of that class, as well as in the construction of private residences and church, school, and other public buildings. Foundation and cellar work was all of this material until within the past fifteen years. Conshohocken limestone has been extensively used for the same purpose; an exception should perhaps be made also in favor of the Trenton brownstone, which has of late years been used to a limited extent for foundations.

Walls of this Schuylkill gneiss, as it is sometimes called, surround the Girard College grounds, the Eastern penitentiary, Laurel Hill, Woodlands, and numerous other cemeteries and public inclosures. Private residences were built of it in vicinities where it could be conveniently quarried, and in the early history of the city it was about the only source of supply for all purposes of stone construction, as may be seen by an examination of such of the structures of the last century and of the early part of the seventeenth century as are yet standing.

The following are among the buildings having foundations of the Schuylkill gneiss. The house in Letitia court, built by order of William Penn, about 1682, the oldest house in Pennsylvania, and said to be the first built within the limits of the city; Old Swedes' church, built in 1698, by settlers from Sweden, and presided over for one hundred and thirty years by pastors sent by the court of Stockholm; Carpenter's hall, built in 1770, and in which the first Continental Congress assembled in 1774; Independence hall, where the Declaration of Independence was signed July 4, 1776; Christ church on Second street, built in 1727, and numerous old-fashioned and now dilapidated brick buildings on Second street and vicinity, which was in ante-Revolutionary days the business and fashionable part of the city.

Although in this locality brick seems to have been the favorite material for superstructures of the more pretentious buildings in early times, in the more northern portions, where the gneiss was at hand in inexhaustible quantities houses were built entirely of this material. Such parts of the original walls of the Belmont mansion, built in 1742 in Fairmount park, as are yet standing, are of the Schuylkill gneiss. The Mount Pleasant mansion, so rich in historic associations, situated on the opposite side of the Schuylkill from Belmont, is built of rectangular blocks of the gneiss. It is the variety which contains considerable feldspar in its composition, and the surface of the stone where exposed to the atmosphere seems inclined to roughen and crumble because of the decomposition of that ingredient. The walls are covered with a heavy coat of paint, which proves to be quite a valuable protection against the decomposing influence of the atmosphere. This house was built about the middle of the last century by Captain John McPherson, and it was purchased and occupied by Benedict Arnold while he was military governor of Philadelphia during the Revolution.

The house of John Penn, built in 1785, and still to be seen in the Zoological Gardens, is of this material, and is also protected by a coat of paint. The effectiveness of paint in protecting the variety of this gneiss, which contains considerable of the vulnerable feldspar in its composition, may also be seen in the portions of the foundations of Christ church which are above ground. In places where it has been abraded the roughening and crumbling process is going on, while the parts covered by paint remain intact.

In Germantown, now a suburb of Philadelphia, the Dutch settlers from the first constructed their houses of the gneiss which underlies the locality. Colonel Timothy Pickering, who was present at the battle of Germantown, writes that most of the houses standing there at that time were of stone. Chief Justice Benjamin Chew's stone house, Clivedon, which is at present occupied by his descendants, and is in a good state of preservation, was assaulted by the light artillery of the Americans during the battle for the purpose of dislodging several companies of British who had taken refuge there, but the masonry proved so solid that no impression was made except to break the windows and doors and destroy the statuary in the inclosed grounds.

The Woodlands, once a private residence occupied by the Hamilton family, built of rough blocks of the Schuylkill gneiss about the time of the Revolution, still stands in Woodlands cemetery. The high massive walls and imposing front of the Eastern penitentiary are built of the same material; also a number of churches in the central and northern portions of the city. This material is generally very distinctly stratified, the plates of mica showing quite plainly the parallel arrangement; but in the older buildings where the stone was used, it was laid

up by the masons indiscriminately, apparently to suit their convenience, much of it being set on edge. This is particularly noticeable in the foundation walls of the Old Swedes' church. The stone seems to bear this treatment of setting on edge unusually well, showing but little disposition to scale off, and the practice still continues to some extent, as was noticed in buildings of recent date, particularly in the case of the buildings of the university of Pennsylvania, the foundations and basement stories of which are built of the gneiss. The treatment of setting on edge detracts something from the solidity and durability of a wall. Stratified rocks where used as building stone should invariably be laid the bed way.

An examination of many pretentious buildings of stone in this city shows that this important principle even now is often disregarded, sometimes in the case of stones least capable of withstanding such treatment. In one instance a huge rectangular block of brownstone serving as the base of a fine Corinthian column 6 feet in diameter was observed to be set on edge and already much defaced by the spalling off of the stone in thick slices. If the same block had been set the bed way, which it would seem could have been done quite as conveniently, no such injurious consequences would have resulted. Many of the stones used here for building purposes when set on edge will stand considerably less compression than where set bed way, as is demonstrated by crushing tests.

PENNSYLVANIA MARBLE.—The next source from which Philadelphia early began to draw building material was the marble in the limestone basin of Montgomery county. This is a narrow isolated strip of what is called by Rogers the Auroral limestone, the Siluro-Cambrian limestone of Professor Lesley in the *Reports of the Second Geological Survey of Pennsylvania*, and which is so important a feature farther to the northward in the Kittatinny or Cumberland valley. This material appears to have been first quarried by Daniel Hitner, about the time of the Revolution, or shortly afterward, (*a*) and from its close proximity to the city and its superiority in point of beauty to the Schuylkill gneiss, which had been the principal source of supply to builders up to this time, its use steadily increased from the first. Until 1825 it was transported to the city by teams, but about this time the completion of the Schuylkill canal afforded superior means of transportation and gave a great impulse to the use of this marble for building purposes in Philadelphia. In many parts of the city at the present time block after block may be seen having window caps and sills, and in many cases base courses and steps of this material. Of late years, however, New England marble is also largely used for these purposes.

The Montgomery County marble is distinguished from the other marbles in use here by its bluish color and coarser texture, the peculiarities of appearance being such as to make it easily recognizable after being once observed. It continued to be the only material used in the better class of stone construction from the time of its introduction to about 1840, when a new era was entered upon by the gradual introduction of brownstone, granites, and marbles from more distant points. During its reign of popularity many fine public buildings were constructed of it, among which are the Girard bank, built in 1798, the custom-house in 1819, United States mint in 1829, naval asylum in 1830, Merchants' exchange in 1832, and Girard college, begun in 1833. The sarcophagi in which rest the bodies of George and Martha Washington, at Mount Vernon, were wrought of this marble. A sarcophagus for Henry Clay, of Kentucky, is also said to have been made of it. Its reputation for durability is of the highest, but the superiority in point of beauty of the marbles from Vermont and Massachusetts and the Italian marble excludes it from the highest class of architecture, though it is now extensively used in that large class of stone-work wherein beauty is a secondary consideration, as for coping, inclosures, bases of monuments, and all the less ornamental class of work in cemeteries. Monuments are also frequently made of it, and in point of durability they often prove equal or superior to those made of the finer marbles.

Of the buildings constructed of Pennsylvania marble, the main Girard College building is by far the most considerable. This structure, well known as one of the finest specimens of Corinthian architecture in the world, is of Montgomery County marble, except the columns, bases of columns and architraves, which are of marble from Egremont, Massachusetts. There is much connected with this building calculated to offer a profitable subject for study to all who are interested in stone construction. The wide portico, extending entirely around the building, and supported by massive fluted columns, protects the outer walls entirely from wet, thus leaving scarcely any part of the building exposed to the destructive elements, excepting the marble roof and the outer steps, parts readily replaced when they have yielded to the effects of time. No combustible material enters into its construction nor into that of any of the accessory buildings designed for the accommodation of its pupils, and the ample grounds with which it is surrounded secure it from any injurious effects that might arise from the burning of adjacent buildings.

Since the transportation facilities by rail and water have enabled builders to choose their materials from a wide list, fashion seems to have dominated here to such an extent, as to private residences especially, that particular building stones have had their periods of popularity, some longer, and some shorter, when they were used for the better class of work to the partial exclusion of other stones.

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The following list of some of the most important buildings, with the dates or approximate dates of construction, will give a general idea of the time of introduction as well as of the periods of greatest popularity of each of the principal building stones that have been in use here from the first settlement of the city up to the present time:

Material.	Name of building.	Date of construction.
Schuylkill gneiss	Penn (Letitia) mansion (foundation)	1682
	Old Swedes' church (foundation)	1698
	Christ church (foundation)	1727
	Old state-house (foundation)	1732
	Belmont mansion	1742
	Mount Pleasant mansion	1760
	Church, Saint James of Kingsessing	1762
	Mennonite church	1770
	Chew house, or Clivedon	1770
	Carpenter's hall (foundation)	1770
	Woodlands mansion	1775
	Solitude	1785
	Eastern penitentiary	1823
	Seminary of Saint Vincent de Paul	1876
Pennsylvania (Montgomery county) marble	Girard bank	1798
	United States custom-house	1819
	United States mint	1829
	United States naval asylum	1830
	Merchant's exchange	1832
	Girard college	1833
Granite from—		
Quincy, Massachusetts	Moyamensing prison	1835
Cape Ann, Massachusetts	Woodlands Cemetery gateway	1850
Quincy, Massachusetts	Swaim's building, Chestnut street	1850–'60
	Elliot's building, Chestnut street	1850–'60
	Leland's building, Chestnut street	1850–'60
	Jayne's building, Chestnut street	1850–'60
	Dunbar's building, Chestnut street	1850–'60
	Mellor & Williamson's building, Chestnut street	1850–'60
	Jayne's building, Third street	1850–'60
	Leland's building, Third street	1850–'60
	Cope & Co.'s building, Market street	1850–'60
	Thurlow Hughes & Co., Fifth street	1850–'60
	Commercial bank	1850–'60
	Philadelphia National bank	1850–'60
	American Sunday-School Union	1850–'60
	First National bank	1865
Cape Ann, Massachusetts	Provident Life and Trust building	1865
Quincy, Massachusetts	Manufacturers' bank	1868
	French, Richards & Co.'s building	1869
	Pennsylvania Life and Trust Company building	1870
	Pennsylvania Railroad offices	1870
Cape Ann and Fox island, Maine	New Masonic temple (the porch is of Quincy granite)	1872
Concord, New Hampshire	Presbyterian Board of Publication	1873
Westerly, Rhode Island	New York Mutual Life Insurance building	1875
Concord and Richmond	Memorial hall	1876
Cape Ann and Quincy	Ridgeway library	1876
Dix island and Richmond	New post-office	Unfinished.
Connecticut brownstone	Moyamensing prison (east front)	1835
	SS. Peter and Paul's Catholic cathedral (front)	1846
	Saint Mark's P. E. church	1849
	Bank of Commerce	1850
	Bank of North America	1850
	Girard hotel	1850
	Old Masonic temple	1853
	Academy of Music (trimmings)	1855
	Holy Trinity Episcopal church	1857
	First Baptist church	1857
	Saint Clement's P. E. church	1859
	Fifth Baptist church	1863
	Union League house (trimmings)	1864
Picton sandstone from Nova Scotia and New Brunswick.	Harrison private residence	1851
	Sharpless Brothers' block	1858
	Strawbridge & Clothier block	1860
	Continental hotel	1860

Material.	Name of building.	Date of construction.
Marble from—		
Lee, Massachusetts	Farmers' and Mechanics' bank	1854
Vermont	Hamah private residence	1855
	Third National bank	1863
	Homer & Collady block	1866
Lee, Massachusetts	Dr. Jayne's private residence	1867
Vermont	Baldwin's building	1868
	White's building, corner Twelfth and Chestnut streets	1869
	Fidelity block	1869
Vermont and Lee, Massachusetts	G. W. Childs' private residence	1871
Vermont	Philadelphia Trust and Safe Deposit	1874
Lee, Massachusetts	Saint George's hall (except front)	1876
Vermont	Bullitt building	1879
Lee, Massachusetts	New city buildings	Unfinished.
Serpentine, Chester county	Beth Eden church	1868
	University of Pennsylvania	1871
	Memorial Baptist church	1874
	Holy Communion church	1875
	Girls' normal school	1876
	Academy of Natural Sciences	1876
Ohio sandstone	Young Men's Christian Association	1868
	Academy of Fine Arts (trimmings)	1870
	Residence of Edmondield Moore	1875
	Girls' normal school (trimmings)	1876
	Academy of Natural Sciences (trimmings)	1876
	Second Reformed Episcopal church	1878
	Horticultural hall (trimmings)	1881
	New city building (trimmings)	Unfinished.
	Saint Agatha's church, Roman Catholic (partly)	
	Saint Luke's Episcopal church (partly)	
Hummelstown, Pennsylvania, brownstone.	Academy of Fine Arts (basement)	1870
	Holy Communion church (trimmings)	1875
	Academy of Natural Sciences (basement)	1876
	Philadelphia library (trimmings)	1877
	Building corner Fourth and Chestnut (trimmings)	1882
	Building corner Third and Walnut (trimmings)	1882
	Building corner Fifth and Walnut (trimmings)	1882
	Building corner Twenty-second and Walnut (trimmings)	1882
	Building corner Eighteenth and Spruce (trimmings)	1882

GRANITE.—The Moyamensing prison, built (1835) in gothic castle style, principally of Quincy granite, was probably the first building in Philadelphia in which granite was used. There is a streak of rust on the outside of the wall running down from each embrasure of the battlement, caused apparently by the streams of water directed through these openings in rainy weather. Parts of the wall protected from the streams of water retain their original color, a little dulled by time.

Among the most notable buildings of granite in Philadelphia are:

The new Masonic temple, Norman style of architecture, said to be the finest structure belonging to the order in the world. The porch is a very elaborate and ornate piece of work of Quincy granite.

The Ridgeway Library, Grecian architecture, situated in the center of ample grounds so as to be protected from injury by the burning of adjacent buildings—an advantage not possessed by some of the fine structures of granite here.

Memorial hall, erected to commemorate the one hundredth anniversary of the independence of the United States, is of the modern renaissance style of architecture, and cost $1,500,000; it has also extensive grounds surrounding it in Fairmount park.

The new post-office building on Chestnut street, a most beautiful structure of the French renaissance style, is approaching completion, and will cost when finished about $4,000,000.

The particular kinds of granite from which the buildings above mentioned are constructed are given in a list of the granite buildings. Cape Ann and Quincy are the kinds of granite most used in Philadelphia for general building purposes—the Quincy, which takes a superior polish, for the more ornamental work, and the Cape Ann for rougher work.

The polished red-granite columns in the fronts of many of the business and public buildings are mostly of Bay of Fundy granite; Maine, Quincy pink, and Aberdeen Scotch granite being also used to some extent for the same purpose. The bluish gray polished columns are of Quincy granite. Concord, New Hampshire; Westerly, Rhode Island; Dix island, Maine; Richmond, Virginia, and other points have also furnished considerable of that material for general building purposes in Philadelphia.

CONNECTICUT BROWNSTONE.—That portion of the Philadelphia County prison formerly used for the debtors' department was built about 1835, of Connecticut brownstone, and is among the first, if not the very first, instance of its use as a building material in Philadelphia. The nature of the stone seems to have been but little understood by the builders, as the blocks are nearly all set on edge, evidently for the purpose of making the material "go" as far as possible, as well as to facilitate the dressing. The blocks are exfoliating and separating into layers. Occasional blocks set the bedway are still sound. Experienced builders here say that this stone should be quarried before the winter, so that it may receive a certain seasoning, in order that the frost acting on the natural dampness within a block on being first quarried may not disintegrate it. In the old Masonic temple, Chestnut street, built of Connecticut brownstone in 1853, the rather slender carved ornamentation of the cathedral style of architecture at the top of its front had to be removed on account of its falling off piece by piece. This disintegration was probably due to the exposed position at the top of a high building and to the slender character of the work.

The principal use of this stone here has been for fronts of private residences, three-fifths or more of the fine stone fronts of private residences on Walnut, Chestnut, Spruce, and other principal streets being of this material One of its most noticeable characteristics is the fresh, new appearance which it always retains, and in buildings here, where the material has been handled properly, it has shown itself to be substantial and durable. It is estimated that, including the Trenton, New Jersey, and the Yardleyville and Hummelstown, Pennsylvania, with the Connecticut brownstone, the geological formation to which they all belong (generally ascribed to the Triassic period), has furnished the material for about one-fourth of the whole number of stone buildings now standing in Philadelphia. The materials from this formation quarried at the different places above mentioned, and used in Philadelphia, though having some characteristics in common, are widely different in some respects. The Connecticut stone is of a lively and pleasing reddish-brown color; that from Trenton, New Jersey, and Yardleyville, Pennsylvania, known as the Trenton brownstone, is of a dull, grayish-brown color, and the Hummelstown stone a peculiar bluish-brown. The Trenton brownstone has been much used here for rubble work in the walls of school buildings and churches, and for foundations. The facility with which it is transported by water down the Delaware favors its use.

The Hummelstown brownstone, the hardest and most compact of all these brownstones, has been introduced here within the last fifteen years, and is used principally for trimmings in buildings of other stones and in brick buildings, giving a very pleasing effect. This stone as yet shows no evidence of disintegration in any of the buildings in which it has been used, and has the reputation here of being quite substantial and durable.

VERMONT AND MASSACHUSETTS MARBLE.—Though many of the more pretentious public edifices in this city were constructed before the introduction of the New England marbles, the most considerable of them all, the new city building now in course of construction, is of Lee, Massachusetts, marble, similar to that in the wings of the Capitol at Washington. Pennsylvania marble is used in some of its inner arched passage-ways, Ohio sandstone for some of its trimmings, Bay of Fundy red and Quincy granite for polished columns, and Richmond granite for foundation walls. It is estimated that the cost of this building when completed will be $10,000,000.

The Fidelity block, Baptist Publication Society's building, Third National bank, private residence of G. W. Childs, esq., that of Dr. Jayne, the Philadelphia Trust and Safe Deposit building, Guy's hotel, and many other equally fine buildings, have been constructed of the Vermont and the Lee, Massachusetts, marbles during the last twenty years. Quite a large proportion of the Vermont marble used here is for trimmings of houses and for monumental and other cemetery work.

OHIO STONE.—Ohio stone, as it is called here, quarried in the Berea grit of the sub-Carboniferous period, at Amherst, Berea, and other places in northern Ohio, has been much used in Philadelphia for fronts of private residences and for trimmings and ornamental work. The Young Men's Christian Association building, the Second Reformed Episcopal church, pyramid of the Gardel monument in Mount Vernon cemetery, and canopy over the soldiers' monument at Girard college are some of the structures of the Ohio stone in Philadelphia.

CHESTER COUNTY SERPENTINE.—The green serpentine of Chester county, Pennsylvania, was quite popular in Philadelphia a few years back, and was extensively used in the construction of churches, school buildings, and private residences, especially in West Philadelphia. It is proving here to be substantial and durable, but there is much difference of taste concerning its color and general appearance. It is customary to trim buildings of the serpentine with brownstone, Ohio, and other building-stones. The buildings of the university of Pennsylvania are the most extensive constructed of this stone.

FOREIGN BUILDING STONES.—Foreign building-stones have not been used in Philadelphia for outside work except in rare instances. There is a front on Walnut street of red sandstone from Carlisle, England, and colored Italian, Lisbon, German, and other foreign marbles have been used slightly for inside ornamental work; the principal part of this work, however, is of Tennessee marble, with some Lake Champlain marble. Occasionally a block of fine statuary marble is imported from Carrara, Italy, and for cemetery work the Serivezzia Italian marble is quite extensively used, though it has been rapidly giving place to the Vermont marbles.

The Pictou sandstone, quarried in Nova Scotia and New Brunswick, a stone resembling the Ohio very much in color, is not at present used in Philadelphia, though a number of business houses and private residences were built of it between 1850 and 1860.

USE OF VARIOUS STONES.—The following estimates received from the most reliable sources accessible show approximately the extent to which some of the principal building stones have been used in Philadelphia during 1881:

	Cubic feet.
Granite	250,000
Marble	135,000
Serpentine (Chester county)	50,000
Connecticut brownstone	25,000
Pennsylvania marble	25,000
Italian marble (cemetery work)	25,000
Hummelstown brownstone	21,000
Ohio sandstone	20,000

The following are estimates of the amounts of some of the principal stones used for paving, rubble work, foundations, inside ornamental work, etc., in Philadelphia during 1881:

North River blue-stone (Pennsylvania and New York), used for sidewalk paving	square feet	1,000,000
Conshohocken limestone, foundations and bridge abutments	cubic feet	200,000
Schuylkill gneiss, foundations and rubble work	do	150,000
Trenton brownstone, foundations and rubble work	do	75,000
Vermont colored marble, inside ornamental work, tiling, etc	do	4,000
Tennessee marble, inside ornamental work	do	2,500

Of the 10,518 stone buildings, including those with stone fronts, within the present limits of the city, it is estimated that about one-fifth of the number are constructed of Schuylkill gneiss; one-fifth of Pennsylvania and New England marble; one-sixth of Connecticut brownstone; one-twelfth of Trenton brownstone; one tenth of Chester County serpentine; one-tenth or less of granite; and the remainder of Ohio sandstone, Hummelstown brownstone, Pictou sandstone, and a few others. Owing, however, to the number of large public buildings, such as the Girard college, new city hall, custom-house, mint, naval asylum, etc., in which marble has been used, and to the custom of trimming brick buildings with marble, the quantity of that material used is probably much greater than that of any of the others mentioned.

Granite being the material used in many large structures, such as Memorial hall, new post-office, Masonic temple, and Ridgeway library, the quantity of it used here will also reach a high figure.

The estimates of the number of buildings of each kind of stone, though carefully made, cannot lay any claim to accuracy, but it is believed that with other data given they are sufficiently close to give a good general idea of the extent to which those materials have been used for purposes of construction in Philadelphia.

Cemeteries.—For the better class of monumental and other cemetery work Vermont marble, Italian marble, and granite from various places are all extensively used in Philadelphia.

The use of granite for the more expensive monuments is steadily gaining ground; Quincy, Cape Ann, Fox Island, Hallowell, Westerly, and Richmond granites are some of the stones used.

Montgomery County or Pennsylvania marble is extensively used for bases, curbing, coping, inclosures, etc., and occasionally for monuments.

Schuylkill gneiss is used to some extent for the rougher parts of the cemetery work. Ohio stone and Connecticut brownstone are used in a few instances for monumental work.

Among the most notable of the many elegant monuments and tombs in the different cemeteries are: The Kane tomb at Laurel Hill, in which lies the body of the celebrated Arctic explorer. It is excavated in a bed of the Schuylkill gneiss and faced with massive granite blocks in Egyptian style. The monument to T. Buchanan Read, at Laurel Hill, a polished granite monolith 30 feet in height; the Gardel monument, in Mount Vernon cemetery, consisting of a pyramid of Berea, Ohio, stone, with life-size statuary, executed at Bruxelles; the Drexel mausoleum, of marble, in Woodlands cemetery; granite shaft in Woodlands cemetery to Admiral Charles Stewart.

In the church-yard of the Old Swedes' church the first tombstones were of soap-stone quarried at Wissahickon, on the Schuylkill, a short distance above Philadelphia. Several of these stones yet remain, bearing dates from 1708 to 1773, and the inscriptions are yet quite legible in most instances, while many of the inscriptions on the marble stones of much later date are effaced. The process of decay in the case of the old marble head-stones appears to be by the dissolving of the carbonate of lime by exposure to the weather, leaving a rough surface, caused by the projection of the more siliceous particles, which finally fall off; the process is repeated, and in time the inscriptions are effaced. Some of the fine marble monumental work of late years in the new cemeteries is protected by canopies of stone.

The soap-stone was also used for tombstones in the yard of Christ church contemporaneously with its use in the Old Swedes' church, and it may be stated that the same material was used for steps, trimmings, etc., until the Pennsylvania marble was introduced for those purposes in the latter part of the last century. The soap-stone was used for trimmings in Christ church, the old state-house, and other buildings of an early date. It is soft and easily wrought, but is of unequal hardness on account of having lumps of imperfectly-crystallized serpentine in its composition, causing it to wear unequally, hence it was rejected as soon as the better-adapted Pennsylvania marble came into use.

The graves of Benjamin Franklin and his wife Deborah, in Christ Church yard, Arch street, have a plain horizontal slab, apparently of Hitner's white Pennsylvania marble, bearing simply the names of the deceased. The stone is undergoing the same process of decay as the other old marble tombstones before described.

Bridges.—The Delaware not being bridged at Philadelphia, on account of the interference it would offer to navigation, the bridge work is confined to the Schuylkill.

In Christian Street bridge Cape Ann granite is used; Girard Avenue bridge, Maine granite; Fairmount bridge, Fox Island granite; Pennsylvania Railroad bridge, Girard avenue, partly of Trenton brownstone—granite and Schuylkill gneiss being also used. Conshohocken limestone, Port Deposit stone, and Conewago granite (trap or diabase) from near Harrisburg have also been used in bridge abutments. The Schuylkill gneiss was the first material used here for the construction of bridge abutments.

Roofing.—Slate for roofing is quite extensively used in Philadelphia, there being abundant supplies of the material within easy reach. Lehigh slate from Lehigh and Northampton counties, and Peach Bottom slate from York county, near Mason and Dixon's line, are extensively used.

The Lehigh slate quarried from strata of Hudson River age resting on the Siluro-Cambrian formation of the great valley known in different parts of it as the Kittatinny, Cumberland, or Shenandoah, is the least expensive and most extensively used. The Peach Bottom slate of Archæan age, of excellent quality as roofing slate, is much used for roofing the better class of buildings.

Street paving.—On the 24th of November, 1718, the common council resolved that—

Whereas several of the inhabitants of the city have voluntarily gone into the paving of ye Kennel to the middle of the streets before their respective tenements with pebble-stone, and many are leveling to follow their example. But for as much as what is already done is very much dammified by the excessive weight of carriages, and will be every day more and more, unless some means are speedily taken to prevent the same, an ordinance is brought to prevent the cartmen and others their carrying such excessive loads.

We learn that the first regular paving of a street was due to an accident. A man on horseback being mired and thrown from his horse, breaking his leg, a subscription was raised and the street paved with pebbles from the river bank. In 1719 many sidewalks were being paved with brick, and the cartway with cobble-stone.

In 1750 the grand jury represented the great need of paved streets, "so as to remedy the extreme dirtiness and miry state of the streets"; but the first general effort worthy of mention to pave the streets was made in 1761–'62, and even then the only means applied to the purpose was that produced by lotteries.

The extreme inconvenience of unpaved thoroughfares was much felt from the beginning, and such old records as are now accessible show that frequent spasmodic attempts to remedy the defect were made, but for a long time little was done, and that little not of a substantial or permanent character.

Some of the streets had their channels or gutters in the middle. In cases where the streets were elevated and had a gutter at each side, they were defended by posts, curbstones not having yet come into use.

The first curbstones were set in Water street, from High street (now Market) to Arch street, about 1786–'88. They were of the Schuylkill gneiss, and some of them yet remain, though in a much worn and battered condition.

For the middle of the street, cobble- and rubble-stones continued to be about the only material used until 1848, when cubical blocks of granite having an edge of about a foot began to be introduced; Chestnut street in front of the custom-house and post-office was paved with the cubical blocks about this time. For some years these large cubical blocks were quite popular for paving purposes. In 1852 an ordinance was passed requiring owners of lots to set heavy granite curbstones between the sidewalk and street where paved with cubical blocks.

In 1854 the mayor was authorized to expend $50,000 in paving streets with the cubical blocks. The cubical-block pavements, though unsurpassed in regard to solidity and durability, soon came to be objectionable, since the surface of the large blocks wore smooth, and hence afforded but an uncertain foothold for horses. This difficulty was sought to be remedied by using small (Belgian) blocks 4 inches square, and a secure foothold for horses was thus obtained, but experience soon showed that with a width of about 4 inches the length of the block might be increased to a foot or more, thus securing a more solid pavement without sacrificing any other merit.

Some of the cubical-block pavement, so much of which was laid when in the zenith of its popularity, about thirty years ago, still remains in Chestnut and some other principal streets.

The following statistics were obtained at the office of the commissioner of highways and from other reliable sources:

Number of miles of paved streets in Philadelphia	900
Number of miles of unpaved streets in Philadelphia	1,100
Number of miles of granite-block pavement	50
Number of miles of cubical, Belgian, etc. (estimated)	2
Number of miles of cobble-stone pavement (estimated)	600
Number of miles of rubble-stone pavement (estimated)	248
Number of miles of pavement of Cape Ann granite (estimated)	44
Number of miles of pavement of Richmond granite (estimated)	3
Number of miles of pavement of Port Deposit gneiss, Schuylkill gneiss, Jersey City trap, North River blue-stone, etc. (estimated)	5

It will be seen by the above statistics that cape Ann, Massachusetts, is the main source of supply for granite blocks. The blocks are shaped at the quarry and shipped here by water.

Each of the principal street railways, by a late ordinance, is required to pave with granite blocks one mile of the street through which it runs; and this is the style of pavement now preferred.

The standard size of this block, 12 by 4 by 6 inches deep, is not rigidly adhered to with regard to the length, the blocks generally varying from 8 to 14 inches in length. Experience has shown that if the width be kept at about 4 inches and the block laid crosswise of the street, a sufficiently good foothold is secured for horses, even though the length should vary considerably. The practice here is to have the block about 4 inches wide, from 8 inches upward in length, and 6 or 7 inches in depth; blocks of these dimensions laid on a bed of gravel seem to give the most satisfactory results.

Sidewalk paving.—The sidewalk paving is left to private enterprise, each owner of a lot paving the sidewalks opposite to it according to circumstances. Brick is the main dependence for this purpose, though North River blue-stone is used almost exclusively for the better class of sidewalk paving. The North River blue-stone is now obtained, not only from Ulster county, New York, and neighboring districts on the Hudson, but from Pike county, Pennsylvania, where beds of flagging of the same formation, and equally well adapted to the purpose, have lately been developed.

The North River blue-stone has the reputation here of being perfectly adapted to the purpose of sidewalk paving. It is readily quarried in flags of the required thickness; the surface is even, the material so hard that there is no perceptible yielding to foot-wear, and there is a peculiar grit that prevents the surface from becoming slippery. It is estimated that there are 100 miles of stone sidewalk paving in the city, the greater part of which is of this stone, which was introduced here as early as 1835, or thereabout. During 1881 about 1,000,000 square feet of North River blue stone was used in Philadelphia for sidewalk paving, and thicker layers of the material are used to some extent for trimmings of houses. The estimate given includes stone brought both from the New York quarries and from those near Pond Eddy and Shohola, in Pike county, Pennsylvania.

The sidewalks in front of some of the larger business houses on Chestnut street are paved with large flags of Cape Ann, Richmond, and other granites, which flags serve also as vault covers. It is found necessary to "ridge" the granite flags, as otherwise they become so slippery as to afford but an insecure foothold for pedestrians.

Slate from Lehigh county, Pennsylvania, has also been made use of to some extent for sidewalk paving. A good example of its conduct when used for flagging is seen in front of Independence hall, where the material is used. Such parts of the pavement as remain whole have a very even surface; but the slates, being laminated or in layers adhering together, are rapidly shelling or separating into thin plates by the action of water and frost.

The Wyoming blue-stone is also used for sidewalk paving to a limited extent, but the flags from the upper layers of these quarries are generally laminated, and, like the Lehigh slate, are disintegrated by water and frost, though the lower layers furnish material free from this objection, and which is in every way excellently adapted to the purpose of paving. The best curbstones in use here are of granite about 8 inches wide, 2 feet deep, and from 6 to 10 feet and upward in length.

Asphalt is but little used for paving in Philadelphia, and is mostly confined to some walks in Fairmount park, and a few small areas laid by private individuals.

PITTSBURGH, PENNSYLVANIA.

Several important buildings were constructed of the local stone (Morgantown sandstone of the *Second Geological Survey of Pennsylvania*), quarried within the limits of Pittsburgh, before its destructible nature was understood. The stone in all these buildings is being rapidly disintegrated by the action of the atmosphere. The native stone, however, in the construction of by far the greater part of the cellar and other underground work, is still used, and is thought to be durable when protected from the atmosphere.

Sandstone from Baden, Beaver county, Pennsylvania, a material easily dressed and durable, is largely employed for foundations, caps, sills, etc. The color of this stone is locally called "pepper and salt", owing to the presence of little brown specks of iron oxide throughout it. This characteristic renders it readily distinguishable from other Beaver County stones; its texture is rather coarse. Sandstone from Homewood, in the same county, is largely used for bridge abutments and for other rough building purposes. It is hard to dress, and hence is not a favorite where fine work is required. It is a durable stone, resisting the action of the atmosphere quite well. The Homewood sandstone is a well-known horizon of the Lower Coal Measures.

The quarries at Freeport, Pennsylvania, which formerly furnished considerable building stone at Pittsburgh, are not operated at present; however, near the last named place, at Lucesco, Westmoreland county, there is a quarry which is beginning to furnish some stone for cellars and foundations at Pittsburgh. Some of the street paving stone and most of the sidewalk paving stone is brought from flag quarries on the Monongahela river, in Allegheny and Fayette counties. It is a very hard bluish colored material, which comes out in convenient shape for flagging, and resists quite well the kind of wear to which it is subjected. One of the principal sources of paving blocks is Banning's quarry, near Connellsville, Fayette county. One or two churches and business blocks are built of Massillon sandstone, which is used to a considerable extent for finer grades of work.

The Smithfield Street German church, constructed of Massillon sandstone, shows signs of crumbling in one or two places. This church was constructed with two disconnected walls side by side; the outside one very thin and with many of the stones on edge, the inside one undressed and carelessly put up. This is but one of many instances in which a stone suffers by being improperly handled rather than through defects in the material itself.

The Ohio sandstone is employed to some extent for the more ornamental stone-work. The Allegheny court-house, built of the Morgantown sandstone quarried in the vicinity, the stone in the walls of which was rapidly disintegrating, was lately burned. The atmosphere of Pittsburgh is severe on building stones. In the large number of iron and other manufacturing establishments an immense amount of bituminous coal is consumed, and a cloud of sulphurous smoke continually envelops the city. At times the fog is so dense that gas must be lighted during the day.

There are two or three buildings constructed of Niagara limestone from Lemont, Illinois, and there is one building—the Dollar Savings bank—with a front of Connecticut brownstone. The streets are largely paved with stone, and besides the paving blocks already mentioned, which are used for the better class of street paving, cobble-stones from the Allegheny river are more extensively used for that purpose than any other material. There is considerable stone sidewalk paving, though brick is generally used for this purpose. For the portions which are of stone, flag-stone from points in Allegheny and Fayette counties is chiefly used. Flagging from Warren, Ohio, is also used to some extent; also sandstone from Baden and Homewood, in Beaver county. The wharves are constructed of cobble stones taken from the bed of the Allegheny river. The abutments of several of the older bridges across the Allegheny and the Monogahela rivers are built of the native stone quarried within the limits of the city of Pittsburgh. Bridge abutments are now built of the massive sandstones from Beaver and Homewood. Sawmill Run wall, which holds up the embankment of the Pittsburgh, Cincinnati, and Saint Louis railroad, along the south bank of the Monongahela river, is built of a sandstone similar to the local stone from the railroad company's quarry near Walker station, Allegheny county. For all first-class cemetery work granite is preferred, owing to the peculiar severity of the atmosphere.

PITTSFIELD, MASSACHUSETTS.

The following is a list of stone buildings in Pittsfield, with the materials of which they are constructed: The Berkshire County court-house, of white marble from Sheffield; the public library, of Longmeadow granite; the house and barn of Mr. Thomas Allen, of Quincy granite; one house built of limestone from New York; farm-house of Mr. A. A. Rice, of cobble-stone found in the vicinity.

There are no important quarries here, and surface stone, stated by Professor C. H. Hitchcock to be of Cambro-Silurian limestone of the Berkshire valley—called the Stockbridge limestone by Professor Emmons—is found in the vicinity and is used for foundations and underpinnings. There are also some small limestone quarries from which the material is obtained for these purposes. The soil everywhere is full of rough limestone blocks of quartzite—cobble-stone of Potsdam sandstone age, according to Professor Hitchcock—and where cellars are dug much of the stone taken from the excavations is broken and used for the walls. In many places in the vicinity the limestone ledge crops out, but has never been quarried to any great depth. The streets are not paved with stone, excepting the gutters, which are usually paved with cobble-stones. The sidewalks of about half a mile of the business streets are paved with North River blue-stone, and the remainder of the sidewalks with concrete. The curbstones are a blue flagging, said to have come from Catskill, with some limestone from a local quarry.

PORTLAND, MAINE.

The material chiefly used for the better class of work is granite from Hallowell, Biddeford, Spruce Head, and Yarmouth. Next in importance is the Nova Scotia sandstone, used for fronts. There are four churches built of material obtained from rough granite bowlders found in the vicinity of Portland; one building is of Vermont marble. Stone for foundations, cellar walls, and work of that class, is rough granite bowlders obtained in the immediate vicinity of the city; underpinnings are of granite from Biddeford, Yarmouth, and Spruce Head; in the steps, posts, and basements of better houses, the following granites appear to have been used: Spruce Head and Biddeford, quite extensively; also Portsmouth, and Hallowell granites; Yarmouth and Hallowell granites are used in fronts, sills, and trimmings. The Spruce Head granite is especially conspicuous by its patches and its freshness even after a long exposure. One old building is fronted with Quincy granite. The granite from the Maine Central quarry at North Jay has been used only in the trimmings of the Maine Central Railroad office. Iron railings in the elaborately-wrought granite supports invariably discolor the blocks; even the smallest piece of iron at a considerable height discolors everything below it. Part of the breakwater in the harbor is built of granite from mount Waldo and Bluehill. Forts Preble, Gorges, and Scammel are of granite from Mount Waldo, Biddeford, Spruce Head and perhaps other places. The post-office is a large and beautiful building of Vermont marble, with fluted columns, and considerable carved work, the best being of Hallowell granite. The custom-house is a very beautiful granite building of Hallowell and Concord granite, the main building being of Concord, while the towers are of Hallowell granite.

The city hall, quite a large structure, has a front of fine yellow sandstone from Nova Scotia and a basement of granite. Several churches and the Emory block are built of granite, chiefly from Hallowell; also, some are built of irregular pieces of sappy slate and mica-schist picked up in the vicinity of Portland, with granite trimmings; one or two of these have square blocks of quarried granite interposed, which give them a peculiar appearance. The Centennial block has a front of red and yellow Nova Scotia sandstone, and two beautiful polished granite columns of material from Red Beach, Maine. The county jail is built of Biddeford granite. Stone is now used exclusively in paving such streets as are paved, and the material formerly used for this purpose was cobble-stones from Cranberry islands and East Maine; the material now used is granite blocks from Yarmouth, Hallowell, and Fox island. There is a small amount of stone in sidewalk pavements, of Hudson River flags, but brick is the material chiefly used for paving. The curbstones are of granite from Falmouth and the vicinity of Portland usually, but granites from Yarmouth and Hallowell, and some from Spruce Head, were so used.

POTTSVILLE, PENNSYLVANIA.

Pottsville is very picturesquely situated close to the foot of the mountains and partially on their sides, all of the ground on which the city is situated being uneven, thus making considerable stone-work necessary for bringing the bases of buildings to a level, and also for terrace walls and other purposes necessary in cities built on very uneven ground. Montgomery County marble has been used to some extent for steps, base courses, sills, and other trimmings; also some Vermont marble for the same purposes. Ohio sandstone was used for trimmings in the *Miners' Journal* building, a fine structure of brick. New England granite has been used in a few important business buildings for steps. Goldsboro' brownstone is used in two or three buildings for trimmings; it approaches Connecticut brownstone in color more nearly than does the Hummelstown of the same formation.

In several buildings the bad effects of placing the stone edgewise instead of the bed way are manifested by the disintegration of the material. Edging proves to be particularly injurious to the brownstone—less so in the case of marble, still less so with the Pottsville conglomerates and laminated granites; but it is desirable to avoid the practice in all cases, as experience proves. The Henry Clay monument, on the side of the hill above the *Miners' Journal* building, is of iron with base of Pottsville conglomerate, a material abundantly exposed near Pottsville. The largest stone structure in the city is the Schuylkill County prison; the front of this building is of Trenton brownstone of Triassic age; the architecture is of the castellated style, and the side and rear walls are constructed of Pottsville conglomerate.

For cemetery work New England and Italian marble, brownstone occasionally, and some granite, have been used. Besides the stone buildings enumerated there are about 200 buildings with considerable stone in their structure in the way of base courses, caps, sills, lintels, and steps. Hummelstown brownstone has been the stone chiefly used for trimmings, it being easier of access than any other stone good for that purpose; it proves here to be substantial, durable, and in every way satisfactory for trimmings. A large rectangular block of this stone was observed serving as steps in front of a business house; although it has been in place twelve years and subjected to continued foot-wear, but little impression has yet been made on it.

None of the streets are paved with stone. The city is so situated that there is perfect drainage in almost all parts, and the gravelly nature of the soil is such that the streets are naturally firm and the need of paving them with stone is not urgent. There is, however, considerable stone sidewalk pavement, chiefly of the sandstone quarried in the vicinity. The North River blue-stone is used to a limited extent for the same purpose. The curbstones are of the native Pottsville conglomerate. The abutments of the small bridges needed are of Pottsville conglomerate. The slate roofs are principally of Lehigh County slate.

POUGHKEEPSIE, NEW YORK.

Stone found in the vicinity of Poughkeepsie, either in small quarries or in excavations of various kinds, is a hard blue limestone suitable for rough work only. As to durability, however, it is indestructible by the ordinary action of the elements. The only stone used here that has shown signs of disintegration is the brownstone, much of which comes from Connecticut. Sills and lintels of this material show signs of disintegration after the lapse of years. Besides the materials already mentioned as used in stone construction, limestone from Westchester county, Ohio sandstone, and gneiss from the vicinity are employed. For foundations and underpinnings hard, blue limestone and other rocks from the small local quarries and from various excavations are used; for underpinnings dressed sandstone and blue-stone are used to a limited extent. Two and a half miles of the principal streets are paved with large cobble-stones, and there are 300 feet of Belgian block pavement. Sidewalks are largely paved with stone, and the material used for this purpose as well as for curbing is the North River blue-stone. Blue-stone and bowlders are used in the construction of buildings, docks, wharves, and bridge abutments.

PROVIDENCE, RHODE ISLAND.

The foundations in the city of Providence are generally from the so-called ledge stone from the great quarry in Cranston and smaller ones in North and East Providence, a slate of great strength in resisting strains. It is very hard to break across the grain. In digging for foundations in this city miry ground is occasionally struck, and quicksand is often encountered. The great length of blocks attainable and the strength of the slate make it very serviceable for filling up such ground, because the slate does not break into smaller pieces by the strain upon it. In the case of the Providence gas-house the reason given for making the dome of great size is said to be the desirability of relieving the pressure on the lower parts of the building on account of the unfavorable condition of the ground. In the older buildings the Quincy granite and Connecticut sandstone are chiefly used for underpinnings, especially the latter; and the Nipmuck stone and Smithfield granite are also used to a considerable extent for this purpose. The other granites were brought into use lately, and have been extensively employed also. In one or two houses a blue-stone, probably of Hudson River age, has been used. As regards the sidewalks, Providence uses much concrete. The Bolton, Connecticut, flags were once employed very extensively and are still found, but none are sold now in the city. Very often there exists in them tongues of harder rock in the soft blue schist, and by the wearing of frost and water the stone becomes grooved in a very peculiar manner, with the tongues standing out as ridges. This softness and want of homogeneousness must be serious defects. In old times large amounts of crossings, flags, and even curbs were hauled into the city from Nipmuck ledge, from near Coventry; they are distinguished from others by their yellow look. The same stone has been used in some old dwelling-houses; it has quite a large proportion of muscovite, with much less biotite in layers, and hence splits quite smoothly, so that it is designated by Providence architects as "natural face" stone. Trimmings of white and blue Vermont marble are used in one or two buildings, and artificial stone has also been used. Tuckahoe dolomite is used in one front and for trimmings in one or two buildings, and two old posts before a house are capped with this same material. There is a great tendency in the newer buildings to use fine red brick with yellow sandstone trimmings. The finest stone structure in the city is the new city hall. It is built of Hurricane Island, Westerly, and Concord granites. The basement up to the pencil mark is of Hurricane Island granite; above this the front and right sides are all Westerly except the columns, which are Concord granite; the back and left sides above the basement are Concord granite. The granite slabs on the sidewalk of the new city hall, obtained from the Cape Ann Quarry Company, are claimed to be the largest granite flags quarried in this country. The dimensions are from 22 to 23 feet long, 5½ to 8 feet wide, and 1 foot deep; some are from 10 to 12 feet wide, but the width is usually less. These different granites harmonize perfectly. The building is said to have cost $1,400,000. Polished columns of Westerly granite support the lamps. The stone in the soldiers' and sailors' monument in front of the city hall is of Westerly granite; the United States post-office and custom-house of Quincy granite; the Providence athenæum has front and columns of Quincy granite and sides of Smithfield granite. In front of it is a very beautiful drinking fountain, said to be of light Concord granite, and two handsome polished columns of Quincy pink granite. The new court-house just opposite is a magnificent brick building extensively trimmed with red sandstone, partly carved, and in the entrance stand six polished columns, two of red Westerly, two of blue Westerly, and two of Diamond Hill granite. The arcade runs from street to street, and was erected in 1828. The twelve large columns are made of Smithfield granite, and must have been a large undertaking at that time.

The high school is of brick with yellow sandstone trimmings; it has a high basement built of Westerly granite and polished columns of red Westerly and Quincy pink granites; the Roger Williams monument is of Westerly granite; the new Catholic cathedral, the most imposing stone building, is entirely of brown sandstone from Portland, Connecticut; Grace church is built of Little Falls, New Jersey, sandstone; the First Congregational church is of granite from Smithfield; All Saints' Memorial church and Saint Stephen's church are of Connecticut brownstone; Saint Mary's church is of granite from Westerly, Diamond Hill, and Northbridge; the Central Congregational church is of Connecticut brown sandstone; Sayles Memorial church at Brown's university is of red Westerly granite trimmed with Connecticut brown sandstone; Saint Xavier's academy is an old stone building made of material from Nipmuck ledge, Coventry, Rhode Island; the Providence Savings institution was built twenty-seven years ago of Quincy granite; there is a handsome private residence near the Friends' school-house built entirely of cut red and white Westerly granite; Saint Patrick's church is built of rough stone from the vicinity; the gateway of the North burial-ground is built of Diamond Hill granite; in Grace Church cemetery the posts, coping, etc., are made of West Greenwich granite; the Dexter asylum has an immense stone wall of natural-faced stone from Nipmuck, in the vicinity of Providence; the old state prison is built chiefly of Quincy granite; the Burgess building is fronted with Tuckahoe dolomite; the Richmond building is of brick trimmed with olive sandstone, and has red and gray polished granite columns; the Wilcox building has some carved and polished work of Westerly granite in its composition; the Aldrich house has a front of white limestone which came from the city of Montreal, Canada; each block was sent on dressed into the proper shape and numbered. This quarry is said to be within the limits of Montreal. Saint John's church is built of bowlders and natural-faced stone from the vicinity of Providence; the building is trimmed with red sandstone. The College Library building of Brown university has a basement of Sterling granite; it is built of brick trimmed with yellow and blue sandstone. There are also red

and gray polished granite columns, probably from Red Beach, Maine, and Diamond Hill. The granite in the pumping-station is from Westerly; there are two wharves in which granite was used extensively; in one the material is from Diamond Hill and the other from Pascoag, Rhode Island.

There are 135 miles of recorded streets; 16 miles of this length are paved with granite blocks and cobble-stones; the material is from Diamond Hill and Westerly, Rhode Island, from Connecticut, and some from Maine granite quarries.

The sidewalks are but little paved with stone, concrete being usually the material employed for this purpose. In such sidewalks as are paved with stone the Hudson River flags are used, with occasionally granite from Diamond Hill and Smithfield, gneissoid granite from Nipmuck, Rhode Island, and flags from Bolton, Connecticut. The curbstones are of granite from Diamond Hill, Smithfield, Westerly, and Nipmuck; and Hudson River blue-stone is used to a limited extent for this purpose.

QUINCY, MASSACHUSETTS.

The seven stone buildings in this place are constructed of Quincy granite. All the stone used for building is obtained from the quarries within the city limits. The streets and sidewalks are not paved with stone, but there are some curbs of the material from the local quarries. Among the important stone buildings are the town hall, the Unitarian church, and the school building.

READING, PENNSYLVANIA.

Quarries of the Siluro-Cambrian formation are operated within the limits of Reading for local building purposes. The material at this point, however, is used only for the rougher building purposes, such as foundations, underpinnings, etc. Stone is not used to any great extent; there is an abundance of brown sandstone south of the town, the northern edge of the formation which furnishes the brown sandstone passing within a short distance of it. No extensive quarries of this material are being operated in the neighborhood; what stone is needed for local use in Reading and vicinity is obtained from the surface bowlders. Much of the material in this locality is a conglomerate, and only the surface bowlders have as yet been made use of; consequently the stone, well seasoned and tested by the weather before being used, proves to be durable. The buildings of this sandstone are usually in a good state of preservation. For the better class of stone construction Hummelstown brownstone is the material most used. The stone used for bridge abutments and arches is the brown sandstone already mentioned; none of the streets are paved with stone; some of the sidewalks are paved with Hudson River blue-stone, but the amount is small. The curbstones are made of local limestone and Hudson River blue-stone. Bricks of good quality are manufactured in the vicinity, and the Philadelphia pressed brick is also being largely used.

RICHMOND, INDIANA.

Stone is but little used in the construction of buildings in Richmond, and is chiefly confined to foundations; the material employed for this purpose is the Cincinnati blue limestone, outcrops of which are found along a creek in the vicinity. The stone from this formation at nearly every point where it is exposed or quarried shows itself to be lacking in the important quality of durability, and its use here has demonstrated that after a comparatively short exposure to the atmosphere it begins to weather. The ground on which the city is built furnishes secure foundations, and there are no conditions of topography or of climate that are especially unfavorable to the extensive use of stone as a building material, although the stone from the Cincinnati formation quarried in the vicinity is used for foundations and for the ruder purposes generally; the twenty stone buildings are constructed of Berea, Ohio, sandstone of sub-Carboniferous age. The streets are not paved with stone, and the sidewalks but very little; the material used in such streets and curbings as are paved is limestone from New Paris, Ohio.

RICHMOND, VIRGINIA.

There are but five buildings in Richmond constructed of stone, four entirely of stone and one front. In two of the buildings granite quarried in the vicinity is used; and in the walls of two buildings stone from surface bowlders found in the vicinity is used, while one building is of Quincy, Massachusetts, granite. There is a one-story building on Main street, between Nineteenth and Twentieth streets, which has stood for more than a century; it is constructed of bowlders of granite rock, and has no significance in an inquiry concerning stones used in construction, except to show the durability of these bowlders. The stone used in a church on Grace street was obtained from a quarry below the city, but it has been practically abandoned. The stone used in the custom-house came chiefly from the Old Dominion Granite Company, and there is scarcely any change perceptible in the material since it was laid in the walls of the building. The pedestal of the Washington monument is constructed of granite from the Tuckahoe district, Henrico county. The piers of the five bridges across the James river at Richmond were constructed of

stone quarried for the most part on the island in the river and along the right bank of the river not far from the ends of the bridge. There are several docks where this material is also largely used. The granite quarried near Richmond ranks with the best granites, and it has been used in the construction of many important public buildings throughout the country, notably the superstructure of the new State, War, and Navy Department building in Washington, District of Columbia. In the business portions of the city the streets are paved with cobble- and rubble-stones from the vicinity. The sidewalks are but little paved with stone, and the materials used are the mica-schist from Lynchburg, and North River blue-stone shipped from Rondout, New York. The curbstones are of the local granite.

ROCHESTER, NEW YORK.

The materials used in stone construction in Rochester are, for foundations and underpinnings, limestone from the local quarries, and to a limited extent sandstone from Ohio and from Albion, New York. For the better class of stone construction, Ohio sandstone, Medina sandstone from Albion, and granite and limestone from the vicinity, are all used. By far the larger number of stone buildings are constructed of limestone from the vicinity. For piers and work of that class done by contract Waterloo limestone is used. The streets are largely paved with Medina sandstone rock from Albion, New York; and there is considerable stone sidewalk, the material used being Medina sandstone and Hudson River blue-stone. Curbstones are principally of the latter.

ROME, NEW YORK.

Most of the buildings in Rome are of brick or wood—largely of brick. The foundations and underpinnings are built of limestone and sandstone quarried at Higginsville and Verona, Oneida county. For the better class of stone construction sandstones from Verona and Potsdam, New York, and limestone from Onondaga and Oneida counties are used. There is little stone street pavement; the material used is cobble-stone. There are about 12 miles of stone sidewalk pavements of sandstone from Cayuga county, New York, and Hudson River blue-stone. There is but little curbing.

RUTLAND, VERMONT.

As there are quite celebrated marbles quarried in the immediate vicinity of Rutland, that is the chief material used in stone construction. Considering the convenient source of supply for building stone the number of the stone buildings in the city is not large, there being only twelve constructed entirely of this material and one front of marble. The following are some of the principal stone buildings in the vicinity: Two mills at Sutherland Falls are built of marble quarried at that place; the Episcopal church is constructed of gray limestone; the Catholic church is of limestone taken from the lot upon which it is built; the old jail, now used as a dwelling, is also of limestone; the Chatterton dwelling-houses near Sutherland Falls are of limestone; Sheldon & Slason's 2 mills, store, and office are of West Rutland marble; the Catholic church, H. H. Brown's store and office, the mill of Gilson & Woodfin, and that of the Manhattan Company are of the same material.

The population of Rutland is scattered over a wide area, the principal village being comparatively small. The unusual number of stone buildings is due to the proximity of the marble quarries. This material is used not only for the better class of construction, but also for foundations and underpinnings, and for all ordinary purposes. The location of the quarries is north and west of the town. Slate from Fair Haven and Chester, Vermont, is also employed to a limited extent for foundations and underpinnings. The streets are not paved with stone, and about a mile of sidewalk pavement is of marble and slate, and a little of granite from Chester, Vermont. The curbstones are of marble, slate, and granite.

SAINT PAUL, MINNESOTA.

In the enumeration of stone buildings in Saint Paul every business front having separate numbers, though included in the same block with others, was counted as one building, and the number of stone buildings given in the tabulation includes every stone structure whether large or small. The use of stone in Saint Paul has exceeded that in Minneapolis on account of the ease of quarrying and its accessibility, and the comparatively greater cost of wood. The great lumber mills are at Minneapolis, and their products would have to be hauled by wagon or by steam a distance of ten miles to make them available at Saint Paul. The following is a list of Saint Paul buildings with materials of which they are constructed:

Structures with brick walls and Berea sandstone fronts	4
Structures with brick walls and Saint Paul limestone trimmings	208
Structures with brick walls and Kasota calciferous sand-rock trimmings	107
Structures with brick walls and Frontenac dolomite trimmings	49
Structures with brick walls and Fond du Lac limestone trimmings	7
Structures with brick walls and Berea, Ohio, sandstone trimmings	30
Structures with brick walls and Vermont marble trimmings	1
Structures with brick walls partly trimmed with Minnesota granite	27

The state capitol now in process of construction is to consist essentially of Red Wing pressed brick, with trimmings of the dolomite from Frontenac. At the base of the building one course of brown sandstone from Fond du Lac, Minnesota, will show about 10 inches; the unexposed part of the foundation is of the blue dolomite from the upper part of the Trenton formation, at Saint Paul, which is a much better stone than the beds of this formation that are usually quarried for building purposes. Some of the principal buildings of the city that deserve enumeration are the following: The market building, built of brick, trimmed with Kasota stone; Baptist church, built wholly of Kasota stone; the cathedral is wholly of Saint Paul limestone; the McMullen block and the Fire and Marine Insurance building are of Saint Paul limestone; the Drake business block is of brick, trimmed with Kasota stone and granite; the business block of Auerbach, Finch & Van Slyke, of brick, trimmed with Frontenac stone; the Manheimer business block and the German-American bank are of brick, with Ohio sandstone fronts; the Saint Paul Episcopal church is built of Saint Paul limestone; the United States custom-house is of Saint Paul limestone, with Saint Cloud, Sherburne county, granite trimmings; the Saint Paul rolling-mill is of Saint Paul rock, with Kasota trimmings; the Presbyterian House of Hope church and the piers that support the bridge over the Mississippi river are of Saint Paul limestone; the trimmings of Lindeke's, Warner & Sherman's, Barney's, Gilfillan's, and Odd Fellows' blocks are of the magnesian limestone from Frontenac, Goodhue county, Minnesota; the front of the Nichols & Dean block is of granite from Sauk Rapids, Minnesota.

The streets are but little paved with stone, wooden blocks having been chiefly used for this purpose. The sidewalks in the business parts of the city are very generally paved with Saint Paul limestone and granite from Minnesota, sandstone from Ohio, and the calciferous sandstone of Kasota. Curbstones are of the Saint Paul limestones.

SALEM, MASSACHUSETTS.

In the few buildings in Salem in which stone enters as an important ingredient, Cape Ann granite, Peabody granite, and Springfield sandstone are the materials used. Foundations and underpinnings are of Cape Ann and Peabody granites. There is considerable stone street pavement of Cape Ann and Maine granites. Sidewalks are not paved with stone, but the curbs are of Cape Ann and Peabody granites.

SALT LAKE CITY, UTAH.

The assembly house is built of Cottonwood granite, and the old tabernacle has piers of Red Bud sandstone. The new Mormon temple is to be constructed of the Cottonwood granite. On account of the greater cost, stone is used to only a limited extent: brick, adobe, and wood being well adapted to the climate and much less expensive than stone. Of the forty stone buildings in the city the Red Bud sandstone was used in the construction of over thirty, and three or four were built of granite quarried in Little Cottonwood cañon; and in such foundations as are built of stone these materials are employed, though bricks are chiefly used for foundations. The streets and sidewalks are not paved with stone.

SANDUSKY, OHIO.

The city of Sandusky has a much larger percentage of stone buildings than any other city in Ohio. Of buildings entirely constructed of stone it has absolutely by far the largest number of any Ohio city, owing to the cheap and abundant supply of good building stone within the limits of the city, which constitutes a great limestone quarry covered with but a very shallow layer of soil or earth. The stripping rarely amounts to 2 feet, and below there lie from 8 to 10 feet of easily-quarried, strong, and durable limestone of good color, and in every way adapted to all building purposes. In early days it was the cheapest building material accessible, and so came to be used in many of the houses first built in the city.

The white limestone that lies immediately below the blue is reached but in a single city quarry; this is a massive stone fit for dimension work and well adapted to cutting, but the great supply of it comes from Kelley's island and point Marblehead. The blue limestone from the city quarries is largely used in the construction of piers and docks in the vicinity, and also for flagging, but it is not very well adapted to this use; it is laid in blocks or slabs from 4 to 8 feet square, not very smooth until polished by wear, and then becoming dangerously smooth. The stone of the city all proves very durable and the best of foundations are secured at small expense. The Sandusky court-house is of the Massillon sandstone. The streets and roadways are chiefly macadamized with broken blue limestone.

SAN FRANCISCO, CALIFORNIA.

The first stone structures in San Francisco were two buildings erected in 1854, of granite brought from China, quarried and dressed in that country. In the years 1856–'57 the granite quarries of Folsom were opened, and the fronts of several buildings on Montgomery and Battery streets were constructed of it. In 1865 the Bank of California building was erected of a beautiful blue sandstone quarried at Angel island, in the bay of San Francisco; it holds its color and surface well. The earthquake of 1868 made some cracks in the walls and gave rise to the belief that the

stone was weak, and that stone in general was not fitted for use in this region. The United States mint has a basement of granite and walls of sandstone, from New Castle island, in the gulf of Georgia, British Columbia. There are six fluted columns, 27 feet high by 5 feet 6 inches at the base and 4 feet 6 inches at the top, of New Castle sandstone. The new city hall is the most extensive building in San Francisco. The walls are of brick, but the foundation is of rubble from Angel island. Considerable granite is used in the basement and steps from the quarries at Rocklin and Penryn near the American river, in Placer county. The window-sills, key-stones, and balustrade are of sandstone from San José, in Santa Barbara county; the corridor floors are marble from Vermont and Massachusetts, and black marble from Glens Falls, New York. The Penryn granite, from the quarry of Griffith & Griffith, was employed in the construction of the basement of the United States mint, water-table of new City hall, dry-dock at Mare island, the new Stock Exchange and the Real Estate Associates' buildings. The people are afraid of stone buildings on account of their being cracked by earthquakes, and most of the large business buildings are of iron. The foundations and underpinnings are of granite, rubble from the vicinity of the city and from Folsom and Penryn and Napa, and sandstone from San José. There are about 46 miles of streets paved with cobble-stones, basalt, and granite from Sonora and Penryn. A few of the sidewalks are paved with granite from Folsom, and Vermont slate. Curbs are of granite from the various quarries which supply the city with this material. There are 11,000 feet of sea-wall constructed of rubble from Telegraph hill. The San Francisco dry-dock is constructed of granite from Folsom. The terrace walls and basements of the buildings of Messrs. Stanford, Hopkins, and Cooks are built of basalt from Sonora. Penryn granite is largely used in brick and iron structures as steps, sills, stairways, and window-caps.

SARATOGA, NEW YORK.

The stones used in Saratoga are mostly blue limestone from rocks of Trenton age quarried near the town. Foundations are built of this stone. Ohio sandstone and Connecticut brownstone are used for trimmings in some of the large buildings. Brick has been employed in the construction of the large hotels and other public buildings. Most of the streets are macadamized with cobble-stone and broken limestone. Broadway has about three-quarters of a mile of cobble-stone pavement. The sidewalks are mainly laid with brick, excepting in the business part of the town, where the North River blue-stone and a little Vermont marble are laid on the curbs of the cross sidewalks with blue limestones from the vicinity.

SAVANNAH, GEORGIA.

The nearest stone quarry to the city of Savannah is located near Milledgeville, in this state, distant about 175 miles. The granite at that point is excellent, but being difficult to work on account of its hardness, no systematic effort to introduce it here has been made. Most of the granite is in use for steps and window- and door-sills, brought from Stone mountain, near Atlanta. The Presbyterian church is a large granite building, with a wooden steeple The custom-house is built entirely of granite. These are known as stone buildings, and the materials in both case came from Quincy, Massachusetts. Cobble-stone for paving material comes as ballast from northern ports. Only the business streets are paved, and the materials used are the cobble-stone and Hudson River blue-stone from New York. A few of the sidewalks are paved with the Hudson River flags.

SCHENECTADY, NEW YORK.

Stone is rarely used in this county except for foundations, and there are not many opportunities of judging of the character of the material used in stone construction. In one or two instances, Saint George's church, for example, the stone from the local quarries when properly laid has proved to be of most excellent quality. It makes, when carefully laid in foundations, very regular faces, and preserves its rich color for an indefinite period: however, when improperly handled by the masons, as when set on edge, it is liable to exfoliate to such an extent that it becomes necessary to substitute new blocks of stone. It may be so handled as to form substantial and durable walls in stone structures. All the streets are paved with cobble-stones, from 4 to 6 inches in diameter, found on the surface of the ground in the vicinity. The sidewalks are paved with stone 5 feet wide and 2 inches thick, from the Helderberg formation.

SCRANTON, PENNSYLVANIA.

The Coal Measures are eroded from the mountain ridges on either side, leaving the Seral-Conglomerate Pocono sandstone and Catskill sandstone exposed on their sides and crests. These sandstones furnish most of the stone for ordinary purposes of construction in the city.

The amount of stone construction is but trifling: the most important building—the new court-house—is now in course of construction, and is located in what was once a deep swamp: the foundations are 30 feet in depth and constructed of the Seral-Conglomerate quarried at Shanty hill, in the vicinity of Scranton. The superstructure is to be of Catskill sandstone quarried in the mountain ridge just west of Scranton, and the heavy trimmings of Devonian limestone from near Syracuse, New York.

For bridge abutments the Catskill sandstone quarried in the mountains near Scranton is used; it is extremely hard, withstanding exposure, and is easily quarried in regular blocks suitable for the purpose. Only two streets are paved with stone, and the material used in these instances is cobble-stone from the stream. There is considerable stone sidewalk paving, and the material for the purpose is brought from Nicholson, Wyoming county, Pennsylvania; also some from Brandt, Susquehanna county; Lehigh slate is used to a limited extent for the same purpose. The curbstones are Catskill sandstone quarried in the vicinity.

SPRINGFIELD, MASSACHUSETTS.

Brick is largely used for the purposes of construction in Springfield, to the exclusion of stone. In addition to the number of stone buildings enumerated which are built of Longmeadow sandstone and Monson granite, those two materials are frequently employed for sills, cornices, and other trimmings. A few buildings have trimmings of Ohio sandstone; none of these materials show signs of decay, as the stone structures are all of recent date. The upper part of the city is built on terraces of stratified sand; the lower part has some foundations in clay, and in places piles are driven before laying foundations; these are thought to be in the old channel of the river on the lower terrace; some settling has been noticed under the spires of two churches, but this is attributed to faulty construction and not to the ground. The foundations and underpinnings are chiefly of Longmeadow sandstone. The streets are macadamized with trap from Westfield, and a few of the sidewalks are paved with Hudson River flags and granite flags from Monson. Curbstones are of Monson gneiss and Longmeadow sandstone.

SPRINGFIELD, OHIO.

Stone from the upper or Springfield division of the Niagara formation is quarried in the vicinity of this city, and is used for the less ornamental classes of construction. The stone from the quarries here is chiefly used in rough work, such as cellar walls, bridges, sewers, and the like. The Episcopal church edifice, on High street, Springfield, is built of this stone in the rough, and displays fine architectural effect. The Central high school was built of limestone from the local quarries. As very few buildings of this kind have been put up in this city, scarcely any judgment can be made of the Springfield stone; for other and rougher work it has stood the test of time for half a century or more. The site of the city is well adapted to buildings of weight; indeed but few feet in depth would place buildings upon solid strata of the Niagara limestone. The Portsmouth and the Berea sandstones have both been used to a limited extent for trimmings. But few of the streets are paved, and those are paved with cobble stones and macadamized with the local limestone. Sidewalks are but little paved with stone, and the material used is the Springfield and Dayton limestones; also to a very limited extent the Berea and Portsmouth sandstones. For bridge abutments, sewers, and work of that class the limestone from the home quarries is employed. Whether it is set on edge or as in the natural bed seems to make less difference with this material than with most building stones.

STEUBENVILLE, OHIO.

Material for all stone construction in this place is quarried in the vicinity from the beds of sandstone in the Upper Coal Measures. The material is durable and comparatively pleasing in appearance, and is used for caps, sills, corners, and other trimmings. The Jefferson County court-house is the only building of importance in which stone from a distance is used; this structure is built of Amherst, Ohio, sandstone. Of the buildings enumerated as having stone fronts, none have fronts entirely of stone. The principal church and McGowan's block are built of sandstone from local quarries. Considerable of the cemetery work, such as monuments, bases, and inclosures, is made of sandstone from a local quarry. This material is susceptible of fine carving, though it is of rather coarse texture. The wharves in Steubenville are constructed of cobble-stones taken from the Ohio river at low water. The abutments of the Pan Handle Railroad bridge across the Ohio river at this point, and the water-works, are also constructed of the local sandstone. In such streets as are paved cobble-stones from the Ohio river are the material used. There is but little stone sidewalk pavement, and the material for this purpose is obtained from local quarries.

TAUNTON, MASSACHUSETTS.

In the vicinity of Taunton there are several small ledges which are worked occasionally for a short time when wall stones are needed for some particular building. The irregularity with which these openings are worked does not admit of their being enumerated with important quarries. Their product is a bluish "wall" or "mortar" stone, similar to a material quarried near Lowell, Massachusetts. Of the eight stone buildings in Taunton three are built of granite from Acushnet, and five of the "mortar" stone from the vicinity. The foundations and underpinnings are of the local mortar stone and Acushnet granite. The streets are but little paved with stone, the material used being cobble from the fields in the vicinity. A few of the sidewalks are paved with Acushnet granite, and curbs are of the same material.

TERRE HAUTE, INDIANA.

Stone is but little used in this city, but that employed comes from quarries that furnish the best building stone in the state—those of Bedford, Ellettsville, and Stinesville. There is no building constructed entirely of stone, and the number of stone fronts, chiefly of the materials above mentioned, is about 100. Brick is used for foundations because of its cheapness, the impression here being that a stone foundation costs as much as an entire building constructed of wood. Sandstone that may be found near is not suitable for use in construction.

TOLEDO, OHIO.

Toledo is so situated as to have ready access by water to noted quarry regions, such as Amherst and Berea, Kelley's island, point Marblehead, and other places in the vicinity of Sandusky. The stone for the rougher building purposes is the limestone from Sandusky, point Marblehead, and vicinity; that for the better class of construction is chiefly sandstone from Amherst and Berea. In one building constructed of the Sandusky limestone the wall has been broken by frost, to which it is said to have been subjected before the material was out of the quarry long enough to be thoroughly seasoned. Out of 140 miles of sidewalk there are 3.6 miles paved with stone; the total length of the streets is 271 miles; total length of pavements 44½ miles, of which 7¼ miles are paved with Medina sandstone; 4 miles with small bowlders picked up from the surrounding country; 3 miles macadamized with sandstone; 3¼ miles paved with cedar blocks; and 27 miles are paved with plank. Some of the sandstone used in the outside walls of buildings has been set on edge, consequently the color resulting from weathering is not uniform.

TOPEKA, KANSAS.

The stone found in the vicinity of Topeka is an impure limestone suitable for foundations, underpinnings, and work of that class. The other materials used here to a limited extent are sandstone from Warrensburg, Missouri, and limestone from Cottonwood, Chase county, and from Junction City. This latter can be sawed with an ordinary tooth-saw, is full of chert concretions, and is subject to discoloration when exposed; it is not now used. The Cottonwood limestone is a good, strong, substantial material; it can be obtained in masses of from one to five cubic yards, and is now being used for the foundation of the main building of the state capitol.

Safford limestone is a very fine material, composed almost wholly of shells in an unbroken state, takes a good polish, and is quite durable; it is used for steps, trimmings, and curbing.

The Warrensburg sandstone is gray in color and is used for fronts, but in other places to a greater extent than here, and has given satisfaction. A red sandstone found in Colorado, near Pueblo, is used for trimmings; it forms a fine contrast with native limestone. The streets are not paved with stone; the sidewalks are paved with a flagging of a slate formation found in Osage county and sandstone flagging from near Fort Scott, Kansas. The college building, female seminary, and the state insane asylum are built of native stone (magnesian limestone of Permian age) found in the vicinity of Topeka. This material is not suitable for fine trimmings. The west wing of the state capitol was built of limestone from Cottonwood quarry; the United States post-office buildings, now in course of erection, are of the soft limestone found in Crowley county. The east wing of the state-house was built of limestone from Junction City, Davis county.

TRENTON, NEW JERSEY.

Among the stone buildings of Trenton the most prominent are: Of Ohio sandstone: The United States government building. Of Trenton sandstone: The state capitol, the state prison, Saint Mary's Roman Catholic cathedral, Warren Street Presbyterian church, State Street Presbyterian church, Prospect Street Presbyterian church, State Street Methodist Episcopal church, Clinton Avenue Baptist church, Bishop Scarborough's residence, James Moses' residence, John Moses' residence, Richie's private residence, the Pennsylvania Railroad depot. Of Connecticut brownstone: The front of Taylor hall.

Of the buildings enumerated, the United States government building is a new structure and presents a fine appearance. The brown sandstone or freestone of the Greensburg quarries, sometimes known as Trenton freestone, is very largely used for house trimmings, as sills, lintels, caps, and steps; also for table-tops, etc. Montgomery county, Pennsylvania, marble is also used to some extent for trimmings with Philadelphia and Trenton pressed brick, but the use of the freestone is increasing while that of the marble is diminishing. North River blue-stone is also used to some extent for the same purposes. Trenton is very largely built of brick, as Philadelphia and Trenton pressed or front brick are conveniently had, and at comparatively low rates, being less expensive than stone.

The Pennsylvania Railroad Company's bridge crossing the Delaware river has abutments and piers of Greensburg brownstone; the abutments and piers of the wagon bridge over the Delaware are also constructed of the same material, as are the locks, walls, and feeder of the Delaware and Raritan canal.

The majority of the streets are paved; and in such streets as are paved, stone from Lambertville, New Jersey, and some granite are used.

The following is a statement showing the extent of stone pavement in Trenton:

	Feet.
Belgian block	14,170
Cobble-stones	2,880
Telford macadamized	3,000

There is considerable sidewalk pavement on the principal streets, and the material used is blue-stone from the North River quarries, and stone from the quarries at Medford, Hunterdon county, New Jersey. North River blue-stone is used for curbs.

TROY, NEW YORK.

The materials used for stone construction in Troy, for foundations and underpinnings, are shale, quarried in the vicinity, and similar material quarried near Schenectady. For the better class of stone construction Connecticut brownstone from Portland, limestone from the Upper Aqueduct quarry and from near Niskayuna, are the principal materials. The bridge abutments are of shale and Upper Aqueduct limestone; some limestone is also brought from the Lower Aqueduct quarry, but it is not as durable as the Upper Aqueduct limestone. The streets are largely paved with granite blocks from Clarke's island, Maine, and from Weehawken, New Jersey. The sidewalks are largely paved with blue stone, brought chiefly from Malden, New York; and mica-schist from western Massachusetts is used to some extent for the same purpose. Curbs are of blue-stone from Malden, New York.

UTICA, NEW YORK.

There is an abundance of good building stone within a short distance of Utica, and until recently the rates of transportation have made brick a cheaper building material. The sandstone of the immediate vicinity has been used most largely for foundations, but at present, for heavy buildings the limestone of the Trenton formation is used. The sandstone is not durable enough for heavy foundations; it was largely used in former years as stone for cross-walks and the like, but was found to flake under heavy traffic. There are no peculiarities of the ground that render it difficult to use stone for building purposes, but, owing to the comparative cheapness of brick and lumber, it has been considered expensive. There are within the limits of the city sixteen iron bridges over the Erie canal, the abutments of which are built of limestone from Little Falls, New York; also three bridges over the Chenango canal, the abutments of which are built of Cayuga sandstone. There is one block in the city faced with marble. The weigh-lock and house of the Erie canal is of Little Falls limestone. For foundations and underpinnings for the rougher purposes of stone construction sandstone from the local quarries is used; also, to a very limited extent, limestone from Canajoharie, New York. The streets are largely paved with stone, and the material used is cobble-stone; also Medina sandstone, and stone from Hammond, New York. The sidewalks are largely paved with Cayuga sandstone and Hudson River blue-stone.

WATERBURY, CONNECTICUT.

The stone quarried in and about Waterbury is a coarse, hard, granitic rock, and is irregular in many respects as to color, hardness, and general appearance, though most of it is very hard, and there are places in some of the quarries where blocks, regular as to shape and uniform in texture, may be extracted. It is an excellent stone for foundations and for cellar walls, but, unless selected with great care, it is of little use for other purposes. The streets are not paved; about half a mile of the sidewalks is paved with North River blue stone, with curbs of the same material.

WATERTOWN, NEW YORK.

Watertown lies on both sides of Black river, whose rapid currents have worn a channel through the limestone rock, composed of blue limestone, Birdseye and Trenton. Some of the fine churches and grist-mills and factories were built of limestone, but at present brick is used in the construction of such buildings, it being less expensive, although the limestone is easily worked and very durable.

The limestone rock is very much grooved and striated in places by the passage of glaciers, especially where they cross the Black river. The Lorain shale, so called by geologists, is native in the town of Lorain; the rocks of the county present an interesting field for geologists. There are exposures here of the Upper and the Lower Silurian rocks. The limestone rock of the Black River valley is studded with fossils of animal life that existed only in the sea; cephalopods are bedded in the blue limestone, which is comparatively pure carbonate of lime, but is very brittle; otherwise it is durable and susceptible of a fine polish. There is in this vicinity what is called Scotch granite, and also a marble known as Carrara marble. They are probably so called from their resemblance to the Aberdeen Scotch granite, and to the rare Carrara Italian marble, respectively. These were lately discovered in large quantities, which lay in perpendicular strata. Talc is found in large quantities and is being manufactured; it lies generally between Archæan rocks, and often unconformable to those which are in regular strata, and make beautiful flagging stones for sidewalks.

WASHINGTON, DISTRICT OF COLUMBIA.

The formations in the vicinity of Washington are made up chiefly of sand, gravel, and clay, with some isolated bowlders detached from the primitive rocks lying to the north and west. North of Rock creek the rocks of Archæan age are exposed, and ledges of mica-schist of this age have been quarried in and about Georgetown since the first settlements were made. It has been employed chiefly for the ruder purposes of construction, such as foundations, terrace walls, rubble pavements, and work of that class. The most important structure built of it is the new Georgetown College building. It was employed in the foundations of the Executive mansion, the Treasury building, and in those of most of the other public buildings in which the Acquia Creek sandstone was used for superstructure. A chapel in Oak Hill cemetery, built after the style of the time of Henry VIII, is of this material, trimmed with Seneca sandstone.

Mr. George P. Merrill, of the Smithsonian Institution, made careful field observations and examined specimens and microscopic sections of the different varieties of this rock, and reported as follows:

The rock quarried in the vicinity of Washington, and of which the walls of Georgetown college and various other public buildings are composed, is a compact mica-schist of a structure and texture varying from coarsely schistose, splitting easily into thin sheets, and a fine-grained massive rock in which the individual ingredients are so evenly commingled that all traces of stratification are lost. The essential constituents are quartz and mica, the latter being biotite of a deep green color.

Under the microscope numerous accessories are found to be present, among which are epidote, apatite, garnet, magnetite, and rutile, the first-named being the most abundant, while the rutile occurs only as small ocular crystals penetrating the quartz granules. A plagioclastic feldspar is occasionally met with, and in this case the rock approaches gneiss in constitution. The chief objection to the use of this rock for architectural purposes lies in the fact that it frequently contains a large amount of pyrite or iron bisulphide. On being exposed to the air this pyrite becomes oxidized, and the rock disintegrates, or at best is badly stained or discolored. It is this same ingredient that renders many of our sand and lime stones unfit for use, they becoming streaked and spotted with unsightly spots of a rusty red color after being exposed a short time to atmospheric agencies.

In conclusion, I would say that there seems no reason why this rock should not be utilized for building purposes, provided sufficient care be exercised in selecting only such portions as are entirely free from this deleterious substance.

On the Potomac river, 10 miles below the city, at Acquia creek, there is a ledge of light gray and rather coarse sandstone, and quarries of the material were purchased by the United States government in 1791 for the purpose of using it in the construction of the public buildings; the Executive mansion and other older buildings are of Acquia Creek sandstone.

The Executive mansion, or "White House", was commenced in 1792. On September 19, 1793, the corner-stone of the Capitol building was laid by Washington himself, and the central or older portion is constructed entirely of Acquia Creek sandstone from the government quarries. This material was used in the construction of all the important public buildings that were commenced up to 1837. The list includes the Executive mansion, the central or old part of the Capitol building, the old portion of the Treasury building, the old portion of the Patent Office building, and the foundation of the city hall. The Van Ness residence, at the foot of Seventeenth street, was also built of it in 1802.

About 20 miles north of the district, on the Potomac river, the southern edge of the Triassic, or new red sandstone, formation crosses the river, and at this point furnishes the material called "Seneca sandstone", the equivalent of the Connecticut brownstone.

The stone at the mouth of Seneca creek was used in the construction of the Smithsonian Institution building; the *National Republican* building, now used as the Pension Office; the District jail; the front of the Freedman's Bank building, now occupied by the Department of Justice; Lincoln hall; portions of the terraces about the Capitol, Treasury, and other public buildings; the United States prison; the Memorial Lutheran church; and in the trimmings of the chapel in Oak Hill cemetery. When the Chesapeake and Ohio canal was built, in the early part of this century, the Seneca sandstone was much used for locks and dams, especially in that portion of the canal lying near these quarries. In these various situations it has shown remarkable wear and endurance of exposure. This canal constitutes a convenient and inexpensive method of transportation from the Seneca quarries to Washington.

The three materials described, the Potomac mica schist, the Acquia Creek sandstone, and the Seneca sandstone, from their close proximity to Washington and accessibility by water, may be said to constitute the local supply of building stone.

Washington has access by water to all the important quarry regions of the Atlantic coast, and of late years building stones from the localities named below have been used more or less extensively: Granite from the coast of Maine; from cape Ann, Massachusetts; Westerly, Rhode Island; Woodstock, Maryland; and from near Richmond, Virginia. Marbles from Rutland and Sutherland Falls, Vermont; Montgomery county, Pennsylvania; Tuckahoe, Westchester county, New York; Lee, Massachusetts. Hudson River blue-stone from Ulster county and vicinity, in New York. Brownstone from Portland and other places in the Connecticut valley; from Belleville and New Brunswick, New Jersey; Hummelstown, Pennsylvania, and Manassas, Virginia. Slate from Vermont, New York, Pennsylvania, and Buckingham county, Virginia. Gneiss from Port Deposit, Maryland, and sandstone from Nova Scotia.

The materials from distant points began to be introduced about 1840, as at that time the stone from the government quarries at Acquia creek which had been used in the construction of so many important public and

private buildings was found to be so inferior in point of durability and general appearance that the quarries were abandoned and other sources were looked to. An examination of the buildings constructed of the Acquia Creek sandstone shows that numerous clay holes have appeared, caused by the disintegration of portions of the rock from exposure to the atmosphere. Experience with this stone has proved that within a few years, unless constant attention is given to it by filling the clay-holes and covering with a coat of paint, the stone becomes flimsy and unpresentable. All the public buildings in which it was used are painted, both for the sake of preservation and to make them harmonize with the white marbles and light-colored granites that have been used in the construction of additions and extensions, as the exigencies of the public service required the buildings to be enlarged. The two wings of the Capitol are built of Lee (Massachusetts) marble, excepting the columns, which are of Cockeysville (Maryland) marble. The style of architecture is Corinthian.

There is quite a variety of stones used in the interior decoration of the Capitol. The eastern stairway leading to the galleries of the Senate Chamber, the eastern and western stairways leading to the galleries of the Hall of Representatives, and the walls of the Senate reception room (Marble room) are of polished Tennessee marble. There are Ionic columns of breccia or variegated Potomac marble in the apartment of the Supreme Court of the United States; the National Statuary hall, formerly used as the Hall of Representatives, has a circular colonnade of shafts of this material surmounted by capitals of Carrara marble executed in Italy. This stone, when highly polished, presents to the eye an apparently rough and broken surface, which delusion is only dispelled by touching it.

The western stairway to the gallery of the Senate Chamber is of Italian marble, and the statuary in and about the Capitol is chiefly of Carrara and Serivezzia Italian marbles.

Greenough's colossal statue of Washington, in the east park, weighs 12 tons, and was executed in Florence, Italy. The stones used in the terraces, walks, and inclosure-walls about the Capitol are of Seneca sandstone, Lake Champlain marble, North River blue-stone, Rock Creek mica-schist, granite from Maine, Massachusetts, Richmond, Virginia, and other places, and the sub-Carboniferous sandstone from northern Ohio.

The old portion of the Treasury building, commenced in 1836, was constructed of the Acquia Creek sandstone, with foundations of Potomac mica schist. The extensions made to the northeast and west sides of the building were begun in 1855. The material used in the extension is Dix Island, Maine, biotite granite, with foundations of Port Deposit gneiss. The style of the building is Grecian-Ionic. The granite shafts of the colonnades are monoliths. Opposite the north front is an ornate fountain of circular shape, 12 feet in diameter, cut from a solid block of granite. The following materials were used in the walls of the lower story: Stylobate; base, Isle La Motte, Vermont, marble (magnesian limestone); moldings, Bardiglio veined marble from Serivezzia, Italy; styles, dove-colored marble (magnesian limestone) from Pittsford, Vermont; panels, yellow sienna Italian marble; dies, Hawkins County, Tennessee, marble (limestone); above stylobate, pilasters and panels, white-veined Italian marble; styles, yellow sienna Italian marble; panels, Bardiglio veined marble from Serivezzia; cornice, white-veined Italian marble; upper story, stylobate, same as lower; above stylobate, as in lower story, except the panels, which are Pyrennean breccia.

THE STATE, WAR, AND NAVY BUILDING.—The stone used in the superstructure is a light gray biotite granite, quarried near Richmond, Virginia; the basement being of Vinal Haven, Maine, granite. The interior walls of the basement of the southeast wing are built of Seneca sandstone. The tiling of the corridors and passages is of white and black Vermont marble and Lehigh, Pennsylvania, slate. The tiling in nearly all the public buildings in Washington is of the same materials.

There is an example of marble interior decoration in the library of that portion of the building assigned to the Navy Department; the walls of the library are of the following materials: Alps green or verde-antique, a kind of serpentine, yellow sienna Italian marble, French griotte marble, and Lake Champlain red mottled marble.

THE GENERAL POST-OFFICE.—The post-office is of Corinthian style of architecture. The E-street portion, constructed in 1839, of West Chester, New York, snowflake marble (dolomite), was the first important structure in Washington built of marble. In 1855 an extension to the north of the building was commenced, and the material used was marble from Cockeysville, Maryland, with portions of the foundations and facing of the court of granite. The columns of the extension are marble monoliths.

THE PATENT OFFICE BUILDING.—This is considered quite a good specimen of Grecian Doric style of architecture, and covers 2½ acres of ground. The original building, commenced in 1837, is of Acquia Creek sandstone. In 1849 the extension, built of Cockeysville, Maryland, marble, was begun. This extension was added to the northeast and west sides in such a way as to inclose a quadrangle, the walls of which, and the sub-basement of the whole edifice, are built of Maine, Quincy, Massachusetts, and Woodstock, Maryland, granite.

THE SMITHSONIAN INSTITUTION.—The Smithsonian building is constructed of the Seneca sandstone. An examination of the building at the present writing shows it to be firm and substantial, and practically unaffected by any agencies, whether atmospheric or otherwise, except that Mr. Owen described the color of the stone when first quarried as a lilac gray, whereas it is now of a deeper and darker red color, due to its nature. In occasional nooks and corners in shaded portions of the building moss has appeared on the surface. It should be stated, however, that stone which is to be used for building purposes should be carefully selected. The top courses and

others manifestly inferior should be rejected. A little observation reveals that many building stones, especially sandstones, acquire an unfavorable reputation by lack of care in not rejecting the unfit portions, as in nearly all quarries there are layers close to the surface, and sometimes in deeper portions, which are defective and unfit for use.

The building is in style of architecture Norman, dating about the end of the twelfth century, and ranks as one of the best specimens of this style now in existence. The different portions of the edifice, examined separately, are unlike in appearance, yet the general effect is pleasing and harmonious.

THE WASHINGTON MONUMENT.—According to the original design of the Washington monument, an obelisk 600 feet in height and 55 feet square at the base was contemplated. The original foundation was 80 feet square and 16 feet 8 inches in height, 7 feet 8 inches extending below the surface. The wall of the obelisk is 15 feet in thickness at the base, gradually tapering at the rate of a quarter of an inch to the foot on the outside, the inside being perpendicular. The work is now rapidly progressing according to the original design, except that it is proposed to limit the height to 525 feet. The old foundation was pronounced defective by a board of engineers, and was enlarged to 126 feet 6 inches square, a work which was completed in 1880, and was done by excavating 70 per cent. of the earth from beneath the monument and introducing a mass of concrete 13 feet 8 inches in thickness. The great height of this structure, together with the marshy nature of the ground in its vicinity, made it necessary to use more than ordinary precautions in constructing a foundation that could be considered secure. The exterior walls of the shaft are of marble from Cockeysville and Texas, Baltimore county, Maryland, though in the beginning some Lee, Massachusetts, marble was used. The interior walls are chiefly of granite from different places on the coast of Maine. In a report made by Colonel Thomas L. Casey, corps of engineers, United States army, engineer in charge of the construction of the monument, to W. W. Corcoran, esq., chairman of the joint commission for the completion of this structure, dated July 27, 1878, is found the following table. So extraordinary a test of stability is given to the stone by the great weight of the superstructure, that it will be watched closely by builders and engineers as time determines its endurance:

Distance of joint from top in feet.	Contents in cubic feet.	Average weight per cubic foot of masonry in several divisions.	Weight in pounds.	Pressure in tons (2,240 pounds) per square foot. Least.	Mean.	Greatest.	Distance of "line of resistance" from axis in feet.	Stability under action of the wind.
25	.....		.....	.....	.....	.....	0.603	29.454
50	13,555		2,297,650	2.67	2.96	3.26	1.052	17.378
100	34,719	First division .....169.5 pounds.	5,884,973	4.41	5.23	6.04	1.676	11.529
150	63,957		10,840,728	5.85	7.24	8.64	2.087	9.758
171.66	79,239		13,431,081	6.41	8.08	9.72	2.224	9.360
200	101,674		17,195,713	7.14	9.12	11.09	2.383	8.983
250	148,298	Second division.....167.8 pounds.	25,019,140	8.35	10.90	13.44	2.607	8.610
300	204,273		34,411,997	9.54	12.63	15.73	2.779	8.452
343.66	261,191		43,966,055	10.56	14.11	17.66	2.899	8.417
350	272,369		45,816,912	8.28	11.51	14.73	2.892	8.481
400	366,268	Third division .....165.8 pounds.	61,385,397	10.09	13.84	17.60	2.869	8.902
450	470,495		78,666,278	11.76	16.03	20.30	2.889	9.180
500	585,476		97,264,244	13.38	18.02	22.658	2.928	9.413

The mean pressure per square foot upon the lower joint is 18.02 tons, and the maximum pressure brought upon any square foot of the lowest joint under the action of the wind is 22.658 tons. The crushing weight of the marble, as determined by the board above mentioned, is 517 tons per square foot.

Nearly 200 memorial blocks were sent by the different states of the Union, by corporations, lodges, societies, individuals, and foreign countries, to decorate the interior walls of the monument. Blocks of granite came from the various regions of New England, Virginia, Maryland, California, Minnesota; marble and limestone from Vermont, Massachusetts, New York, Pennsylvania, Maryland, Virginia, North Carolina, Ohio, Kansas, Missouri, Iowa, Illinois, Mississippi, and Canada; and sandstone from the Triassic brownstone quarries of Connecticut and New Jersey. The following are some of the stones received from foreign countries: A block from the tomb of Napoleon, island of St. Helena; block of Grecian marble from the temple of Esculapius, presented by the officers of the United States steam frigate Saranac; block from Boo-chow, China; lava from Mount Vesuvius; sandstone said to be from the original chapel built to William Tell in 1358, on lake Luzerne, Switzerland; red syenite (granite) from the Alexandrian library in Egypt; porphyritic biotite granite from the Swiss Confederation; gray biotite gneiss from the empire of Brazil; Grecian marble from the governor and commune of the islands of Paros and Naxos, Grecian archipelago; marble from the Ottoman empire; a block of peculiar and characteristic greenish stone from China; a highly-polished block of red granite from Bremen; Grecian marble from the kingdom of Greece; a head carved between two and three thousand years ago by ancient Egyptians for a temple erected in honor of Augustus, on the banks of the Nile, and set in a block of Italian marble.

Some of the contributions from corporations, societies, and individuals in this country are of Italian marble.

In the following list will be found some of the principal stone structures in Washington and vicinity, with kinds of stone used in their construction:

1. Aquia Creek sandstone.

Executive Mansion.
Capitol building (old portion).
Van Ness residence.
City Hall foundation.
Treasury building (old portion).
Patent Office building (old portion).
Van Ness mausoleum.

2. Potomac mica schist.

Foundation of Executive Mansion.
Foundation of Treasury building.
Foundation of Washington Monument.
Chapel in oak Hill cemetery.
Georgetown College new building.

3. Seneca sandstone.

Smithsonian Institution.
Chapel at Soldiers' Home.
Chapel in Oak Hill cemetery (trimmings; front).
Department of Justice, formerly Freedman's Bank.
District jail.
National Republican office, now Pension Office.
School-house, Second and Potomac streets.
Lincoln Hall.
Cabin John's bridge, parapets and coping.
Memorial Lutheran church.
Sub-basement south wing State, War, and Navy Department building.
Center Market (foundations).

4. Westchester County, New York, marble.

E-street portion of the General Post-Office building.

5. Cockeysville, Maryland, marble.

Exterior walls of Washington Monument.
Columns of the Capitol extension.
Extension of Treasury building.
General Post-Office building (extension).
Ascension church.
Dormitory at Soldiers' Home.

6. Lee, Massachusetts, marble.

Portion of the interior walls of the Washington Monument.
Capitol extension.

7. Maine granite.

Interior of Washington Monument.
Extension of Treasury building.
Basement of new State Department building.
Quadrangle of Patent Office building.

8. Quincy, Massachusetts, granite.

Patent Office (steps, walls, foundations, and basement (partly).

9. Woodstock, granite.

Foundation of the Patent Office building (partly).
National Museum (steps).
Masonic Temple (steps).

10. Port Deposit gneiss.

Foundation of Treasury building (extension).
Saint Dominick's church.

11. Belleville, New Jersey, brownstone.

Corcoran Art Gallery.

12. Manassas, Virginia, brownstone.

District jail (trimmings).

13. Montgomery County, Pennsylvania, marble.

Stone-work at Botanical Garden.
Sarcophagi containing bodies of George and Martha Washington, at Mount Vernon.

14. Cape Ann granite.

Residence of Benjamin F. Butler.

15. Connecticut brownstone.

Foundations and trimmings of E-street Baptist church.
Saint Matthew's hotel.
Arlington hotel (front).
Columbia Institution for the Deaf and Dumb (trimmings).
Masonic Temple (partly).
Residence of Senator William Windom.
Residence of Lieutenant Broadhead (trimmings).
Metropolitan church.
Agricultural building (trimmings).
First Presbyterian church.

16. Nova Scotia sandstone.

Masonic Temple (trimmings).
Colonization building (front).
Riggs house.

17. Richmond, Virginia, granite.

State, War, and Navy building (superstructure).
Bureau of Engraving and Printing (foundations).

18. Ohio sandstone.

National Republican building, now Pension Office (trimmings).
Baltimore and Ohio depot (trimmings).
Lewis Johnson & Co.'s bank.
British Legation building.
National Museum building.
Ex-Governor A. R. Shepherd's block, opposite Farragut statue (Buena Vista stone).
Portland flats.
Capitol grounds, inclosure-walls (partly).
Columbia Institution for the Deaf and Dumb (trimmings; partly).

19. Humelstown brownstone.

Residence of Hon. James G. Blaine (trimmings).
Residence of Senator John Sherman (trimmings).
Residence of Senator J. D. Cameron (trimmings).
Residence of Jerome Bonaparte (trimmings).
Bureau of Engraving and Printing (trimmings).

20. Chester County serpentine.

Residence on Fourteenth street.
Residence on Lowndes row.

21. Vermont marble.

Floors of National Museum building (Swanton Lyonnaise marble).
Walls of library of Navy Department (partly).
Walls of cash-room in Treasury Department (partly).
Corcoran mausoleum, Oak Hill cemetery.

22. Cheat River, West Virginia, sandstone.

Catholic institution between Twelfth and Thirteenth streets.

STONE PAVEMENTS.—In the report for the year ending June 30, 1880, Lieutenant F. V. Green, United States engineer corps, assistant to the engineer commissioner of the District of Columbia, gives the following interesting facts concerning the condition of the streets of Washington on the 1st of July, 1880:

	Square yards.	Miles.
Asphalt and concrete (coal tar)	981,348	40.66
Stone block	411,774	14.87
Rough stone	559,051	18.04
Macadam	215,330	7.45
Gravel	644,993	31.31
Wood	509,481	22.10
Unimproved	1,799,541	95.62
Total	5,121,518	230.05

It is stated that there were in all 1,188,597.47 square yards of wooden pavements, aggregating a length of nearly 50 miles, and costing $4,003,744; that in 1878 there were, exclusive of paving between railway tracks, 790,000 square yards, or 34 miles, of wooden pavements; and that on June 30, 1882, these pavements had been partially replaced to the following extent:

Years.	WITH ASPHALT.		WITH GRANITE.		WITH ASPHALT BLOCK.		TOTAL.	
	Square yards.	Cost.	Square yards.	Cost.	Square yards.	Cost.	Square yards.	Cost.
1878–1879	104,022.52	$200,900 18	56,993.24	$129,657 32	1,093.35	$2,661 61	162,109.11	$333,219 11
1879–1880	67,962.91	104,143 17	45,084.28	87,390 42	3,214.08	6,349 51	116,261.27	197,883 10
Total	171,985.43	305,043 35	102,077.52	217,047 74	4,307.43	9,011 12	278,370.38	531,102 21

The proportion of stone to asphalt laid in two years, from July, 1878, to July, 1880, is as 10 to 17.

The granite-block pavement here is laid on a foundation of gravel and sand, and the joints are filled with cement of coal tar and gravel, as before stated. Of the 18 miles of stone-block pavements 7 miles are composed of North River blue-stone and the balance of granite. The granite comes from various quarries in Maine and cape Ann, Massachusetts, from Westerly, Rhode Island, and from Richmond, Virginia. The texture of the different varieties is quite dissimilar; the finer-grained stones make a smoother surface for a pavement and the coarser ones a more durable surface. Of the 17.50 miles of rough stone pavements 8 miles are composed of cobble (quartz or sandstone drift) and the remainder of rubble, mostly the so-called blue-rock or mica-schist, of Rock creek. A small amount of rubble is of the Seneca stone, which, owing to its more ready attrition, does not prove to be well adapted to paving purposes, excepting for sidewalks.

The macadam pavement is mainly of the mica-schist from Rock creek, but part of it is broken cobble-stone and a part of it flint-stone—that is, quartz found in seamy ledges in the mica-schist formation.

WHEELING, WEST VIRGINIA.

The site of Wheeling is very narrow, on account of the abrupt hills, situated a short distance back from the river, which oblige the city to extend itself to a great length along the stream, as the hills are too abrupt to furnish sites for buildings. The material used in stone construction is the Coal-Measure sandstone quarried in the immediate vicinity, and on the opposite side of the river, in Belmont county, Ohio. This is of sufficiently good quality to answer for all ordinary purposes of construction. For the soldiers' monument in course of construction the material used is granite obtained from the New England Granite Works at Hartford, Connecticut. Strictly speaking, there are no stone fronts in the city, but there is considerable stone in basement stories, corners, and other trimmings. The abutments of the suspension bridge across the Ohio river at Wheeling are constructed of sandstone from the local quarries. The wharves are constructed of cobble-stones gathered from the river at low water, and the streets are nearly all paved with this material. There is a small amount of stone sidewalk paving, and the material used is sandstone from the local quarries and from Buena Vista, Ohio; the Buena Vista stone comes already sawed to the proper dimensions for paving purposes; it stands foot-wear well. The local stone, from its coarser and more granular and friable structure, wears away more rapidly under foot-wear.

WILKESBARRE, PENNSYLVANIA.

Wilkesbarre is located in the celebrated Wyoming valley, which lies between two ranges of the Alleghany mountains, the sandstone of Catskill age being abundantly exposed on their sides and much used in Wilkesbarre for purposes of construction. This material is very durable, but hard and expensive to dress for fine work. One

of the principal quarries of this stone is situated in the mountains 7 or 8 miles east of Wilkesbarre; for the better class of trimmings Wyoming blue stone from Meshoppen is now used almost exclusively, though considerable Catskill red sandstone is also employed for caps, sills, and trimmings generally. The Luzerne prison in Wilkesbarre is the most important stone structure of the place. It is built of Campbell's ledge stone, a siliceous conglomerate of a rich buff color, very substantial and durable. Several fine private residences in Wilkesbarre are constructed of it. There are some buildings trimmed with limestone from near Syracuse, New York. The material chiefly used for foundations and underpinnings is the Catskill red sandstone from the mountains in the vicinity. The Seral-Conglomerate, also quarried near, is used to a less extent for the same purpose. Only two or three streets are paved with stone, and the material used is cobble-stone from the Susquehanna river. The sidewalks are largely paved with stone, the material being the Catskill red sandstone before mentioned, and considerable Wyoming blue-stone from Meshoppen. Lehigh slate is also used to a limited extent for the same purpose. The curbstones are of Catskill red sandstone and Wyoming blue-stone. The bridge abutments in the bridges crossing the Susquehanna river are of Catskill red sandstone.

WILLIAMSPORT, PENNSYLVANIA.

There is no good stone for the better class of construction quarried near Williamsport, and where stone caps, sills, etc., are wanted they are brought from Hummelstown, Pennsylvania, almost exclusively, although some Berea and Amherst stone have been used for trimmings in one building. The Lycoming County court-house is trimmed with Nova Scotia sandstone, which nearly resembles the Ohio sandstone in color and texture. A few buildings have steps of the Montgomery County marble; the steps of the court house are of New England granite, and are becoming slippery from foot-wear. In the cases of the North River blue stone, Wyoming blue-stone, Ohio stone, and others having a sandy grit, there is no tendency to become slippery. The siliceous conglomerate, probably of Seral or Pottsville Conglomerate age, quarried at Ralston, Lycoming county, is the stone most used for steps and base courses; it is quite durable, does not become slippery, and seems to give entire satisfaction. It resembles the conglomerate at Pottsville quite closely. The stone most used for curbing is an even-bedded, slaty stone, easily quarried in suitable shapes for curbing; one piece being observed which was 30 feet long and one foot square at the end, resembling a hewn log. For bridge abutments rough stone from the mountains in the vicinity is used. Stone has heretofore been comparatively little employed at this place. Only one street is paved with stone and the material is rubble from the vicinity. There is but a limited amount of stone sidewalk pavement; the material most used is Wyoming blue-stone from near Meshoppen. Red and light-colored flags quarried in the vicinity are also used for this purpose, and there are a few flags of Ohio sandstone.

WILMINGTON, DELAWARE.

The building stones used in Wilmington are the Connecticut, Ohio, and New Jersey sandstones; marble from Cockeysville and Texas, Maryland; serpentine from Chester county, Pennsylvania; and granites from Brandywine creek, near the city. This last is the most convenient source of supply for the city for ordinary purposes, such as foundations and underpinnings, and for stone street pavements. The sidewalks are not paved with stone; the curbs are granite from Brandywine creek. The Cockeysville marble and the serpentine from Chester county are, however, in easy distance from the city, and have been used extensively. The court-house and a large church are constructed of the serpentine before mentioned, and also a building of Connecticut sandstone. The material in the walls of this building was set on edge, and it exfoliated badly. The following buildings are constructed of the Brandywine stone: Saint John's Protestant Episcopal church, Market street, and the houses of William Brinckly, Kennet street; Edward McIngalls, Eleventh and Jefferson streets; Joab Jackson, Eleventh and Washington streets; William Bush, Browne street; and Edward Tatnall, Market street.

WINONA, MINNESOTA.

Taking into consideration the location and readiness of access to the quarries and the quality of the material, there is no possibility of obtaining a better supply of building stone for use here than material found at Winona, Red Wing, and Stillwater. The stone when freshly quarried is easily wrought, but becomes hard by weathering. The railroad bridge, the jail, the sheriff's residence, and the piers and abutments of Winona bridge across the Mississippi river, are built of Winona limestone. Most of the business blocks are of red brick made near Winona. Some Ohio sandstone has been lately imported for trimmings. Among the other stones used for trimmings are the sandstone from Fond du Lac, Wisconsin, and the lime-rock from Frontenac and Kasota. The streets are not paved with stone, and there is but very little stone sidewalk pavement; the material used for this purpose is lime-rock from Winona.

WOONSOCKET, RHODE ISLAND.

In this place stone is very little employed as a material of construction. The quartzite and mica-schist, especially from the local quarries, have been largely used in building the mills, many of which are stuccoed. Northbridge, Massachusetts, granite and Diamond Hill granite are considerably used for underpinnings in the

better houses. Curbs and crossings are usually of the Northbridge granite; walls are built largely of the local quartzite, which forms the poor man's stone of Woonsocket. The cobble-stones used in some of the buildings are found in the vicinity; in one or two structures Connecticut brown sandstone is employed.

WORCESTER, MASSACHUSETTS.

The houses here are mostly brick and frame structures. The main street contains most of the stone buildings. The local quarry known as Millstone ledge was some time ago given by its owner to the citizens for their free use; it is, however, mostly quarried by one man. The stone is good for common uses, but is not quite uniform in texture, and is too much stained for finer buildings or trimmings. The Arnold row of stores, built of this stone, exhibits its durability, and at the same time its rather unattractive appearance. The firm, sandy clay which forms the site of the city furnishes good foundations. The proportion of houses to inhabitants is large on account of the many small frame structures designed for the accommodation of factory employés. The foundations and underpinnings are of local gneissoid granites from the Millstone ledge. The principal business streets are paved with granite from Fitzwilliam, New Hampshire, and Westford, and the streets and sidewalks are usually paved with local and Fitzwilliam granites. The curbs are of the gneiss from the Millstone ledge. There are nearly 2 miles of stone arch sewers and bridge abutments built of the material from the local quarry. The Fitzwilliam granite is largely brought here by the proprietor of a local quarry. The Messrs. Norcross have constructed fine residences of the Longmeadow sandstone.

YONKERS, NEW YORK.

The stones in the vicinity of Yonkers available for building purposes are the trap bowlders and a very rough gneiss-rock, good only for foundations. For the better class of stone construction brownstone from Portland, Connecticut, and Ohio sandstone are used. There is an aqueduct some 300 feet long and 40 feet high faced with partly rough and partly dressed stone, the rough material of which is broken bowlders of trap, and the cut stone is gneiss from a local quarry. There is also about the town a great deal of retaining-wall made almost entirely of broken bowlders of trap. All these bowlders, of which there seems to be an unlimited supply, are found on or near the surface of the ground, enough being usually found in digging the cellar to build the foundation walls, and often underpinning also. The streets are to some extent macadamized with limestone from Tomkins Cove and with trap-rock and crushed bowlders. This style of paving is known as the Telford paving; in some localities the sidewalks are largely paved with North River blue-stone, as are all the cities which are within easy reach of the blue-stone region. Curbstones are also of this material.

YORK, PENNSYLVANIA.

The Siluro-Cambrian limestone, quarried in the vicinity of York, furnishes all the material that is used for the construction of cellars, foundations, street paving, and road macadamizing. The Goldsboro' brownstone from the Triassic formation in York county is used to a considerable extent. Of the marbles used for caps, sills, curbing, etc., considerable comes from Cockeysville and the town of Texas, near Baltimore, Maryland, some from Montgomery county, Pennsylvania, and some from Vermont and Massachusetts. The Gettysburg granite, a trap-rock precisely similar to the Conewago granite, is much used in York for steps, bases, caps, and sills. It is quarried on the battle-field at Gettysburg. The limestone quarried in the vicinity is the only stone used near York in the construction of bridges. There is a canal wall constructed of it. For steps and curbing, beside the Goldsboro' brownstone, which is principally used, considerable Gettysburg granite is used; also some Richmond, Virginia, granite; marble from Cockeysville, near Baltimore; some Montgomery County marble, and, occasionally, Connecticut brownstone. For base courses Gettysburg granite is used to some extent; for caps, sills, etc., Cockeysville marble, Montgomery County marble, New England marble, and some Gettysburg granite. For hall-ways and office floors, black and white marble tiling prepared in Philadelphia is used. One building is trimmed with the Amherst, Ohio, stone. The streets are nearly all macadamized with the native limestone. Sidewalks are but little paved with stone, and the material chiefly used is the native limestone. Peach Bottom slate, however, is used for this purpose in a few instances. The curbstones are of Goldsboro' brownstone.

ZANESVILLE, OHIO.

The sources for building stone are a ledge of Coal Measures sandstone, quarried in the immediate vicinity. This ledge is a solid mass, about 40 feet in thickness, so that the supply is abundant; by far the larger part of the stone in and about Zanesville is of this material. It is used exclusively in the construction of canal locks, house foundations, excepting occasionally the top courses, and it furnishes a considerable part of sidewalk pavement. Two or three of the oldest buildings in Zanesville are constructed entirely of this stone. It proves to be durable in the walls of buildings, but does not resist foot-wear so well. The stone work of the Clarendon hotel is of the local sandstone. An abundance of this material, the ease with which it may be worked, and its fair quality for all ordinary building purposes, give it the first place in importance among the building stones found in the neighborhood. Another source of supply is the ferriferous limestone near the same horizon.

Chapter VIII.—THE DURABILITY OF BUILDING STONES IN NEW YORK CITY AND VICINITY.(a)

By Alexis A. Julien, Ph. D.

The ravages upon our building stones, by that complex association of forces which we call "the weather", are dangerous and rapid. The indications of interest in regard to the serious results, which are sure to come within a short period, are feeble and evanescent. A brief discussion of the main facts and of the principles involved may aid in forming a basis upon which future investigations may rest. The commissioners, appointed by the Department of the Interior "to test the several specimens of marble offered for the extension of the United States Capitol", said in their report of December 21, 1851:

> Though the art of building has been practiced from the earliest times, and constant demands have been made in every age for the means of determining the best materials, yet the process of ascertaining the strength and durability of stone appears to have received but little definite scientific attention, and the commission, who have never before made this subject a special object of study, have been surprised with unforeseen difficulties at every step of their progress, and have come to the conclusion that the processes usually employed for solving these questions are still in a very unsatisfactory state.

Over thirty years have passed since these words were written, and the same methods are still largely in use, although new instruments and processes and rich discoveries concerning the structure of stone have been made available within a quarter of a century. The facts presented have been gathered from many sources published and unpublished, and from long personal observation. It is but a question of time when careful and thorough investigation for the purpose of determining the best means to avert the coming destruction will be called for. It is necessary first to understand the number and the character of the natural foes which are making this deadly attack.

All varieties of soft, porous, and untested stones are being hurried into the masonry of the buildings of New York city and its vicinity. On many of them the ravages of the weather and the need of the repairer are apparent within five years after their erection, and a resistance to much decay for twenty or thirty years is usually considered wonderful and perfectly satisfactory.

Notwithstanding the general injury to the appearance of the rotten stone, and the enormous losses annually involved in the extensive repairs, painting, or demolition, little concern is yet manifested by either architects, builders, or house-owners. Hardly any department of technical science is so much neglected as that which embraces the study of the nature of stone, and all the varied resources of lithology in chemical, microscopical, and physical methods of investigation, wonderfully developed within the last quarter-century, have never yet been properly applied to the selection and protection of stone as used for building purposes.

The various suburbs and vacant districts have been gradually approaching a character sufficiently settled to justify the erection of entire and numerous blocks of private residences, huge buildings for business offices in the lower part of the city and for family flats in the central and upper wards, besides large numbers of public edifices, storage houses, manufactories, etc. The failure of stone to resist fire in the business district, and the offensive results of discoloration or serious exfoliation, which the poor durability of many varieties of stone has rendered manifest in all parts of the city, have already largely diminished its proportionate use, in reference to brick. Nevertheless great quantities of stone of many kinds are yet introduced, as ashlar or the trimmings of apertures, into the buildings now in progress, and will soon be further employed, if the present activity in building be continued, not only in the private enterprises already mentioned, but in others of more lasting and public importance; *e. g.*, the projected improvements and additions in connection with our water supply, as aqueducts and reservoirs; the new bridges proposed over our rivers; the replacement of our rotting wooden docks by more permanent structures; and perhaps, we may hope, the huge pedestal to support the statue of Liberty on an island in our harbor. As the kinds of building stone brought to this market for these purposes are increasing in number and variety, and their selection and mode of use, as it seems to me, are irregular and indiscriminate, whether from the ignorance or the carelessness likely to prevail in a busy, money-getting community, it would appear proper that a voice of warning should now be heard, calling attention to the dangers involved in the use of bad stone or the bad use of good stone; in the enormous waste and expense soon required for repairs in our severe climate, or in the consequent disuse of stone in favor of brick, by a natural reaction, to the injury of the beauty and comfort of our city.

a From the commercial importance of New York city, the extent of its building operations, and from the enormous scale on which the practical value of building materials is tested in that city, this chapter, though local in title, forms the best available summary upon the durability of building stone for the United States, and is therefore retained in the present form.

There are three classes in the community to which such a warning is addressed:

1. A considerable number of house-owners, to whom it seems to come too late, since they have already expended tens of thousands of dollars in temporary repairs, patching and painting decayed stone, and many of whom have doubtless made rash vows to use hereafter, in construction, brick, iron, terra cotta, wood—anything but stone.

2. House-owners, not yet aware of the coming dilapidation, and who can yet take precautions to delay or prevent its arrival—or others about to build, and who have implicit faith in the eternity of building-stone, since it comes from the "everlasting rock", or at least in a duration which will last their lifetimes—and also a certain proportion of builders and architects willing to learn, and who have much to learn, since the practical scientific study of building stones is yet to be made.

3. And lastly, the architects, builders, and contractors, who know all about the subject, or who do not care what happens to the houses they build, and that large part of our population who never expect to own any houses. To all these the decay of the stone in this city is a matter of indifference, and the quotation presented below—"scarcely a public building of recent date will be in existence a thousand years hence"—few of them, indeed, over a century or two, in fair condition—is only a matter of jest.

1.—EFFECTS OF WEATHERING UPON THE BUILDING STONE OF NEW YORK, ETC.

In foreign countries the subject of the attack of atmospheric agencies on building stones has received much attention, particularly within the last half century, and much earnest effort, though as yet ill-systematized and ill-regulated, has been exerted for their protection by means of the new light and facilities of modern sciences. The contrast between the durability of the stone buildings erected in modern and in the most ancient times is strongly marked:

> In modern Europe, and particularly in Great Britain, there is scarcely a public building, of recent date, which will be in existence a thousand years hence. Many of the most splendid works of modern architecture are hastening to decay in what may be justly called the infancy of their existence, if compared with the dates of public buildings that remain in Italy, in Greece, in Egypt, and the East.—*Gwilt's Encyclopedia of Architecture.*

In England this is largely due to the general use of soft freestones, both sandstones and, especially in London, earthy, loosely compacted limestones. Before the erection of the houses of parliament a royal board of commissioners was appointed for the selection of the proper building stones, and a large amount of information was collected on the subject of the modes and rapidity of weathering of the various building stones throughout the United Kingdom. So difficult and novel, however, was the investigation that the results obtained have been only partially successful, both in the selection of the stone, and, on its incipient attack by the atmosphere of London, in the artificial means suggested for its preservation. Only last year the statement was made, in reference to the building of the royal courts of justice, just erected and inaugurated in London:

> What will be the fate of its exterior carvings and frettings after another fifty years of London smoke, all of us can tell. The same may be said of a thousand other buildings, great and small, that the past generation of Londoners has raised as monuments of its own ignorance of the simplest conditions of good building. They carve their fronts with carvings of flowers and fruit, which in a year the soot will blacken past recovery, and in five years corrode beyond recall.
>
> We see important and costly edifices restored in the lifetime of the architects who designed them, and palaces patched with cement and painted over every three or four years, before their builders have passed away. * * * No remedy has been found for the decay of soft calcareous stone in our smoky cities; and yet, in our childish helplessness, we continue to use it daily and year after year, as if we had no warnings of the folly of doing so. (*a*)

In a recent investigation of the subject, founded largely on a study of the stone monuments in the grave-yards of Edinburgh, Dr. A. Geikie, of the geological survey of Great Britain, has pointed out that in a town the weathering action differs from that which is normal in nature; on the one hand in the formation of sulphuric acid from smoke, causing more rapid decay of stone-work; on the other in the inferior range of temperature in towns and less severe action of frost.

Dr. Geikie also found that sandstones, if siliceous, were sometimes only roughened in two hundred years. When colored the destruction goes on by solution of cement, or of the matrix in which the particles of silica are embedded, *e. g.*, clay, carbonate of lime, and iron and hydrous and anhydrous ferric oxide. In this material he estimated the rate of lowering to amount to three-quarters of an inch in a century.

In the stone of the buildings of New York and adjacent cities the process of disintegration and destruction is widespread, and yearly becoming more prominent and offensive.

GNEISS.—The commissioners of the Croton Aqueduct department, in their annual report for 1862, page 67, make the following statement:

> The retaining-walls of the embankments in many cases require extensive rebuilding. Most of these walls have been constructed of the stone found in their immediate neighborhood—often of a very inferior and perishable character. Thus far we have been able to keep these walls in comparatively good order by removing every year portions of disintegrated stone and replacing them with durable material; but during the past year such large portions, and at so many points, are giving way in mass, that an increased amount must necessarily be expended on them during the coming season.

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a The Builder, 1881, p. 708.

MARBLE.—Italian marble has been found incompetent to withstand the severity of our climate, when used for outdoor work; and of this good illustrations are shown in the pillars, once elegantly polished, in the portico of the church on the southeast corner of Fourth avenue and Twentieth street, etc. The same objection has been urged to the outdoor use of American marbles in our cities, supported at least by their rapid discoloration, but the question is yet unsettled.

Professor Hull observes:

> From the manner in which the buildings and monuments of Italy, formed of calcareous materials, have retained to a wonderful degree the sharpness of their original sculpturing, unless disfigured by the hand of man, it is clear that a dry and smokeless atmosphere is the essential element of durability. In this respect, therefore, the humid sky and gaseous air of British towns must always place the buildings of this country at a comparative disadvantage as regards durability.

And again:

> Under a smokeless atmosphere it is capable of resisting decay for lengthened periods, though it becomes discolored. * * * The perishable nature of the marble when exposed to the smoky atmosphere of a British city, is evinced by the decayed state of the tomb of Chantrey, erected in 1820, in the "God's acre" belonging to St. John's Wood chapel.

Another example of this decay is shown in the group of Queen Anne, etc., erected from Carrara marble, about the beginning of the eighteenth century, before the west front of St. Paul's, in London, England, and which has been covered throughout with a coat of paint in the hope of slightly retarding its inevitable decay. The dolomitic marble of Westchester county has been largely employed in our buildings, and some idea of its character for durability may now be gained. A fine-grained variety was used in the building of the United States assay-office, in Wall street; its surface is now much discolored, and the edges of many of the blocks show cracks. A variety of medium texture was employed in the hotel at the corner of Fulton and Pearl streets, erected in 1823; the surface is decomposed, after the exposure of exactly sixty years, with a gray exterior, in a crust from one-eighth to one-fourth inch in thickness, soft and orange-colored in section. Many crystals have fallen out of the surface on the weathered eastern face, producing a pitted appearance. A very coarse variety has been used in the bank building at Thirty-second street and Broadway, in large part being set on edge; very many of the blocks are more or less cracked, even in the highest story. In the United States Treasury building, in Wall street, a rather coarse dolomite-marble, rich in tremolite and phlogopite, was used, the blocks being laid on bed in the plinth and most of the ashlar, but largely on edge in the pillars, pilasters, etc.: in the latter case vertical fissures commonly mark the decay, but even elsewhere a deep pitting has been produced by the weathering out of the tremolite. The marble used in many other prominent buildings has been improperly laid, *e. g.*, in both of the buildings of the city hall, the Drexel building, at the corner of Broad and Wall streets, the Academy of Design, at Twenty-third street and Fourth avenue, etc. The same process of ultimate ruin in its incipient stages is abundantly shown, even in the marble slabs in Saint Paul's church-yard and monuments of Greenwood cemetery, by discoloration and disintegration of surface. In the United States hotel, on Fulton street, constructed of Westchester marble in 1823, we have the opportunity to study the effect of weathering for over a half century. Though presenting a good appearance at a distance, the stone has become pitted by the falling out of grains, especially on the east side, and is tinged a dirty orange by a crust of decomposition from one-sixteenth to a quarter of an inch in depth.

The horizontal tablets, supported on masonry which has partially settled (*e. g.*, J. G., 1821), generally show a slight curvature in center, only in part, possibly, produced through solution by standing rain-water.

Dolomieu first made the observation on an Italian marble, called betullio, that it possessed a degree of flexibility allied to that of the itacolumite of Brazil. Gwilt states (*Encyclopedia of Architecture*, p. 1274):

> Some extremely fine specimens of white marble are to be seen in the Borghese palace at Rome, which, on being suspended by the center on a hard body, bend very considerably. It is found that statuary marble exposed to the sun acquires, in time, this property, thus indicating a less degree of adhesion of its parts than it naturally possessed.

In the white-marble veneering of the façade of St. Mark's, Venice, the same effect has been observed by Mr. C. M. Burns, jr., in the lower half of a slab of veined marble, 2 inches thick, on the south side of the northernmost of the five portals, just behind the columns and about 5 feet from the pavement. The slab is 11 feet 2 inches long, and 1 foot 6 inches wide; it is hung to the backing by copper hooks driven into the brick work, but the lower part, for a distance of 5 feet 7 inches, bulges out 2¾ inches from the backing.

> The exposure is directly westward, and I found that it became decidedly warm in the afternoon sun, while the backing would be likely to keep its temperature lower. Though the outer surface is somewhat weatherworn, I could not find the slightest tendency to fracture in any part.—*The American Architect and Building News*, 1882, p. 117.

Also at the palace of the Alhambra, in Grenada, Spain, one of the two doors that have been christened "La Mezquita" exhibits an ancient facing of three slabs of marble, the upper resting as a lintel upon the two others, which form uprights, 11 feet in height, 9 inches in width, and only 2½ inches in thickness. At 18½ inches from the top of the door the slab on the right begins to curve and to detach itself from the wall, attaining the distance of 3 inches at about 3 feet from the bottom. From a subsidence of the material of the wall an enormous thrust has been exerted upon the right, and the marble, instead of breaking or of rupturing its casings, has simply bent and curved as if it were wood.—*La Nature*, 1882.

I have also been informed at Sutherland Falls and other quarries near Rutland, Vermont, that the bending of thin slabs of marble exposed to the sunshine in the open air, and accidentally supported only at the ends, has been there repeatedly observed.

Fleurian de Bellevue discovered a dolomite possessed of the same property in the Val-Levantine, of Mount Saint Gothard. Dolomieu attributed the property to "a state of desiccation which has lessened the adherence of the molecules of the stone", and this was supposed to be confirmed by experiments of De Bellevue, who, on heating inflexible varieties of marble, found that they became flexible.

This change, however, cannot be connected with the remarkably small content of water existing in marbles, but with a peculiarity of their texture, which has been briefly discussed by Archibald Geikie (*Proc. Roy. Soc. Edinb.*, 1880), in an interesting investigation on the decay of the stones used in Scotch cemeteries. He has pointed out that the irregular and closely-contiguous grains of calcite which make up a white marble are united by no cement, and have apparently a very feeble coherence.

It appears to me probable also that their contiguous crystallization has left them in a state of tension, on account of which the least force applied, through pressure from without, or of the unsupported weight of the stone, or from internal expansion by heat or frost, produces a separation of the interstitial planes in minute rifts. Such a condition permits a play of the grains upon each other and considerable motion, as illustrated in the commonly-observed sharp foldings of strata of granular limestones, without fractures or faults. In such cases, also, I have observed that the mutual attrition of the grains has been sometimes sufficient to convert their angular, often rhomboidal, original contours into circular outlines, the interstices between the rounded grains being evidently filled up by much smaller fragments and rubbed-off particles; *e. g.*, in the white marble of the anticlinal axis at Sutherland Falls, Vermont.

These results are confirmed by the appearances, familiar to all lithologists, in the study of thin sections of marble, the latent interstices between the grains of calcite having been often developed by the insinuation of films and veinlets of iron-oxide, manganese-oxide, etc. While a polished slab of marble fresh from the stone-yard may not be particularly sensitive to stains, after it has been erected and used as a mantel piece over a fire-place, its increased absorption of ink, fruit-juices, etc., becomes strongly marked. On this property are founded the processes, always preceded by heat, for the artificial coloring of marbles.

In the decay of the marble, largely Italian, in the atmosphere of Edinburgh, Geikie has recognized three phases:

1. Loss of polish, superficial solution, and production of a rough, loosely-granular surface. This is effected, Geikie states, by "exposure for not more than a year or two to our prevalent westerly rains". The solution of the surface may sometimes reach the depth of about a quarter of an inch, and the inscriptions may become almost illegible in sixteen years.

In our own dry climate, however, these results do not appear. The polish often survives ten years in our city cemeteries, and even for over half a century, near the ground, in the suburban cemeteries; in one instance, at Flatbush, it has remained intact for over 150 years, on the tombstone of F. and P. Stryker, dated 1730. Inscriptions are decipherable in Saint Paul's church-yard back to the date of 1798, but about one-tenth are illegible or obliterated: the latter effect was never seen in a single instance on the suburban stones, and is evidently due to the acid vapors in the rain-waters of the city.

2. Incrustation of the marble with a fine-grained, blackish film, sometimes a millimeter in thickness, consisting of town-dust, cemented by calcium sulphate, and thorough internal disintegration of the stone, sufficient, after a century, to cause it to crumble into powder by very slight pressure.

Neither the crust nor any deep disintegration has been observed in the oldest marble tombstones in the cemeteries of New York: their absence is plainly attributable to the inferior humidity of our atmosphere and the absence of smoke from soft coals.

3. Curvature and fracture, observed in slabs of marble, firmly inserted into a solid frame-work of sandstone. This process consists in the bulging out of the marble, accompanied with a series of fractures, and has been accomplished by expansion due to frost. Tombstones are never constructed in this way in our cemeteries; but the curvature of horizontal slabs, observed in Saint Paul's church-yard, produced by the sagging of the supporting masonry beneath the center of the slab, is simply indicative of the flexibility of the material.

Geikie states:

The results of my observations among our burial-grounds show that, save in exceptionally sheltered situations, slabs of marble exposed to the weather in such a climate and atmosphere as that of Edinburgh are entirely destroyed in less than a century. Where this destruction proceeds slowly, comparatively rapid superficial solution and granulation of the stone, the rapid lowering of the surface amounts sometimes to about a third of an inch (or, roughly, 9 millimeters) in a century. Where it is effected by internal displacement, a curvature of 2½ inches, with abundant rents, a partial effacement of the inscription, and a reduction of the marble to a pulverulent condition, may be produced in about forty years, and a total disruption and effacement of the stone within one hundred. It is evident that white marble is here utterly unsuited for out-of-door use.

My own conclusion, from observations in New York, is that, in the cemeteries within the city, the polish on vertical slabs is usually destroyed in about ten years; that the inscriptions are only in small part effaced within from thirty to fifty years, and are for the most part perfectly legible on the oldest tombstones, dating 1798; and that,

although the reduction of the surface to a loose granular condition may reach the depth of ten millimeters, the actual lowering of the surface seldom exceeds 5 or 6 millimeters, the internal disintegration is never sufficient to affect sensibly the strength of the stone during the periods of exposure which have been noted, and a slight flexure, perhaps to the amount of 12 or 15 millimeters, sometimes affects the center of horizontal slabs, 2 meters in length.

In the cemeteries without the city the polish may often survive near the ground, on the faces of vertical slabs, for over one hundred and fifty years, as the granulation of the surface rarely exceeds a depth of 3 or 4 millimeters; and all the inscriptions remain perfect on the oldest vertical tombstones, suffering partial effacement only on horizontal slabs.

Although these facts show the far greater durability of marble in our dry and pure atmosphere, the frequent obliteration of inscriptions, the general, and often rapid, granulation of the surface, and the occasional fissuring of slabs, show that the decay of marble—in the varieties hitherto long used in New York city—is steady, inevitable, and but a question of time; and with Geikie, I, too, am convinced that, if unprotected, such materials are utterly unsuited for out-of-door use, at least for decorative purposes or cemetery records, within the atmosphere of a city.

SANDSTONE.—In regard to brownstone there seems to be a common if not universal opinion—but, in my own view, too hasty, and by no means established—which is presented in the following quotation:

> The days of brownstone fronts for the better class of houses are probably numbered. A thin veneering of soft stone, hooped on to a brick wall, adds almost nothing to the strength of a building. On the exposure of the brownstone fronts for sixty or eighty years to the severity of our climate, in the opinion of intelligent stone-cutters, the majority of them will be in ruins, and the remainder much dilapidated.

In the widely-quoted opinion of one architect, this stone is of no more use for architectural work in this region than so much gingerbread.

Even the brown sandstone of the city hall, originally of a very superior quality, and the crumbling cornices, lintels, etc., of numberless houses which line some of the other streets of the city, evince the progress of the decay. It makes no very great difference whether the stone is laid parallel or perpendicular to its grain. In the former case its destruction is more rapid; in the latter, rottenness soon appears in the lintels, columns, cornices, and other projecting portions of the edifice. Several of the fronts along Fifth avenue, some of them less than ten years old, already look frightful to the experienced eye of an honest stone-cutter.

In regard to the name "Nova Scotia stone", it may be well to explain that it originated many years ago, when grindstone dealers obtained their supplies from some small surface quarries located in and near Nova Scotia. As that stone was of a yellow color, the stone trade has persisted ever since in calling every light-colored stone coming from anywhere in that section "Nova Scotia stone". However, 95 per cent. of the imported stone is derived from New Brunswick (probably 85 per cent. from Dorchester), and the remainder from Nova Scotia and other points. The popular name has been applied to light-colored stones of every quality, quarried at various points of eastern Canada, over a wide section of country, hundreds of square miles in extent, and variously worked out at tide-level, under tide-water, from exposed reefs running out into the sea, or, as at Dorchester, New Brunswick, from a hillside 900 feet high and a quarter of a mile from tide-water. The small quarries usually work out only such stones as they can obtain from outcropping ledges and bowlders, and these are apt to be of bad and varying color, more or less full of iron and other defects; for example, the surface quarries of Hillsboro', New Brunswick, long since abandoned, used in the houses in Forty-second street near Madison avenue, in Second avenue near Fifty-fifth street, some of the bridges in Central park, etc. At the quarries of Dorchester, New Brunswick, it is stated that from 35 to 50 feet of inferior rock and debris are first stripped off to reach the sound rock which is sent to this market. The introduction of this stone into the city as a building material has been too recent to allow any measure of its durability. A little exfoliation may be, however, distinguished near the ground line, and on the sides and posts of stoops, in many cases. Also, in panels, under heavy projecting moldings, cornices, etc., where the sun has no chance to reach and dry up the dampness, the stone molders away slightly over the surface. In the cemeteries it is rarely or never used; in one example, possibly of this material, in Saint Paul's church-yard, (W. J. M., 1841), the decay is plainly beginning around the carvings. The discoloration of good varieties of the stone would be very slow to affect vertical surfaces, properly protected by drips; but on sloping, horizontal, or shaded surfaces, especially near the street level, street-dust is sure to lodge and cling, all the more after the surface becomes roughened by a slight disintegration; while the rough usage to which the stone of balustrades and stoops is always subjected in a busy street, renders this, as well as all other soft varieties of freestone, liable to chipping as well as offensive discoloration (*e. g.*, in the courses, trimmings, and posts of the church on the corner of Forty-second street and Madison avenue, etc.), and unsuitable for use near the ground line.

These freestones from New Brunswick and Nova Scotia, largely employed in our cities, rarely exhibit a laminated structure, and, though a softer stone than the Triassic sandstone just referred to, is rarely affected by exfoliation to any extent, partly perhaps because its introduction into this district has been much later than that of the brownstone. Many instances occur, however, where already an exfoliation has taken place, especially near

the ground line and on peculiarly exposed surfaces, sufficient to mar offensively the appearance of the masonry. This is exceptional it is true, but only a proper investigation or a far longer trial—as yet little exceeding twenty-five years—will establish the fitness of this stone for this climate.

So also the freestone from Amherst, Berea, etc., Ohio, has been used to considerable extent, and in one building (on the corner of Broadway and Barclay streets) has stood well for twenty years. Its rich content of quartz, said to reach 97 per cent. in the buff stone from Amherst, renders this one of the most promising, in regard to durability, of all the freestones of the sandstone class yet introduced here. Buildings constructed of this material in this city since 1857 (*e. g.*, on the corner of Barclay street and Broadway, on the corner of Howard and Crosby streets, etc.), show no decay, but only discoloration. In other instances (*e. g.*, rows of houses on Fiftieth street, west of Fifth avenue, on Madison avenue between Thirty-fourth and Forty-third streets, etc.) the blackened discoloration and frequent chipping of edges of the soft stone are quite offensive. On the other hand, it must be admitted that a stone which cleans itself by the disintegration of its surface, the grains dropping out and so carrying away the dirt, as in the poorer and softer varieties of brownstone or of Nova Scotia stone, is by that very action still more objectionable from its want of durability; and the discoloration of the Ohio stone is offset, at least in part, in the best varieties, by their hardness and promise of durability. Nevertheless, all these light-colored freestones from New Brunswick or Ohio, as well as the light-colored limestones from Indiana, etc., and the light-colored granites from New England, are all open to the special objection of most offensive discoloration (described beyond) shown here in abundant instances as in the cities of the west. This is more likely to affect inclined than vertical surfaces, and those near the level of the street, *i. e.*, within the reach of deposit of street dust; and the objection might be largely obviated by our builders by discarding the light-colored stones of all kinds from projections (cornices, dressings of doors and windows, etc.), and from our stoops, where the additional softness of some varieties renders them liable to disfigurement from wear and blows (*e. g.*, the blocks of Nova Scotia stone fronts in Madison avenue, above Thirty-fourth street).

MEDINA SANDSTONE.—This material is of recent introduction (*e. g.*, Baptist church on Fifty-seventh street, west of Sixth avenue), and its true durability cannot yet be estimated.

BLUE-STONE (graywacke).—This stone is yearly coming into more general use, and, though somewhat somber in tone and difficult to dress, seems likely to prove a material of remarkable durability. In one building in Twenty-fourth street, between Madison and Fourth avenues, its condition appears to be excellent, after fifteen years' exposure perfectly retaining the tool marks. The variety reported to come from the Wyoming valley (*e. g.*, in the building on the north side of Union square) is really derived, as I am informed by Professor H. L. Fairchild, from Meshoppen, Pennsylvania.

The blue-stone or graywacke of central New York and of Pennsylvania has not only been of general use as a flag-stone, but, in compact varieties, has been yearly coming into greater use in our cities for the purpose of water-tables, ornamental bands, window-sills, etc., and, although not a freestone, has recently been introduced even for the fronts of residences (*e. g.*, on northwest corner of Madison avenue and Seventy-second street). It is likely to be one of the strongest and most durable stones, in my opinion, and, to judge by its weathering in outcrops, will be liable, only after a long exposure, to a reddish-brown discoloration.

LIMESTONE.—The Lockport limestone has been used to a small extent in this city, unfortunately for buildings of importance, since it is a loosely compacted mass made up of fragments of shells, corals, etc., extremely liable to disintegration, apparently more from the action of frost than any other cause. To this stone may be applied the observations of Professor F. A. Abel on the fossiliferous bands in the stone of the island of Portland.(*a*)

Though petrifactions were shown by the results of experiments to impart, in many instances, great additional strength to the stone they frequently give rise by their existence to cavities, sometimes of considerable size, which not only serve to weaken those particular portions of the stone, but may also, if they exist in proximity to exposed surfaces of a block of stone, promote its partial disintegration by the action of frost.

The Lockport stone has evidently owed its rapid disintegration within ten years, wherever used in this city, in part to its careless mode of introduction into masonry. Thus, in the building of the Lenox library, at Seventieth street and Fifth avenue, about 40 per cent. of the material is set on edge, *e. g.*, the alternate receding courses of the ashlar, trimmings of apertures, gate-posts, etc. Consequently it betrayed decay long before the completion, fragments falling out of the face of the stone from the arris of cornices and bands, etc. In the abundant trimmings of the same stone in the building of the Presbyterian hospital in the vicinity the same disintegration is displayed, the surfaces peeling off and filled with fine and deep crevices, and the upright posts, *e. g.*, near the entrance archway or porte-cochère on the south side, in which the bedding-laminæ stand on edge, are already seamed throughout with long cracks, which betoken their steady destruction.

The oolitic stone from Ellettsville and Bedford, Indiana, shows an almost immediate and irregular discoloration, said to be produced by the exudation of oil. The oolite from Caen, France, has also been used in many buildings, and, unless protected by a coating of paint, has shown decay in several instances. Mr. G. Godwin, of London, has stated (*Soc. of Arts*, 1881), that "the Caen stone which was sent to this country (England) could not now be

(*a*) *The Builder*, London, 1863, Vol. XXI, p. 859.

depended on, and ought not to be used for external work". The extensive decay of this, with other oolitic and magnesian limestones, in the walls of Westminster abbey, has recently caused great alarm, and will necessitate the renewal of its outer masonry at enormous expense.

One of the most thorough investigations, in regard to the porosity of a series of American building stones, was made by Dr. T. S. Hunt in 1864, and with the following conclusion (*Chemical and Geological Essays*, p. 164):

Other things being equal, it may probably be said that the value of a stone for building purposes is inversely as its porosity or absorbing power. From the results given on 30 specimens, the following may be here quoted as pertinent to stones used in New York city:

No. of specimen.	Absorption.	Percentage.
1. Potsdam sandstone, hard and white	0.50 to	3.96 *a*
2. Medina sandstone	3.31 to	4.04
3. Ohio sandstone	9.59 to	10.22
3. Caen limestone	14.48 to	16.05

Of course the proviso, "other things being equal," covers a great deal of important ground, including the solvency of the material of a stone in the acidified rain waters of a city. Some of the most impervious and non-absorbent readily decompose; while others, which are porous or even cellular, may afford an excellent resistance to decay. But judged in regard to both points, porosity and solvency, the Caen stone may be safely rejected hereafter as unfit for our climate.

Other limestones, oolitic or fine granular, have been brought into use in small quantity, but remain as yet untested by the conditions of our climate.

GRANITE.—As to granite, its tendency to decomposition, termed the "maladie du granit" by Dolomieu, depends chiefly upon climatic conditions. These differ vastly, it is well known, in this region and in that of the great granite builders, the Egyptians. The obelisk of Heliopolis has stood for three thousand years, and is still in good condition. So, too, the obelisk of Luxor had stood for forty centuries in Egypt without being perceptibly affected by that climate, but since its transport to Paris, in the reign of Louis Philippe, it is reported as the result of but forty years' exposure—

to be covered with small cracks, and blanched, and evidently will crumble into fragments before four centuries have passed.

We have transported another obelisk, "Cleopatra's Needle", from Egypt, and, in defiance of the still greater dangers incident to our severe climate, have erected it, covered with delicate carvings, upon a hillock in Central park, exposed to our blazing sun, pelting rain, and biting frost, often successively within twenty-four hours—a monument to the public ignorance in regard to the protection of even our prized possessions—that indifference of our community to the practical value of science which was exemplified through its officials by wantonly paving the walks of the same park with the fragments of the restoration casts of Saurians, after their construction for three years by Waterhouse Hawkins. Granite is also found in many other of our larger buildings, both public and private, but as few of these exceed forty or fifty years in age, and all contain the most durable varieties of that stone, the effects of weathering are only beginning to appear. The bluish variety from Quincy, Massachusetts, has been used in many buildings and rarely shows as yet many signs of decay. In the United States custom house, on Wall street, most of the large blocks appear laid "on bed", but, nevertheless, show some pitting in places, by the attack and partial removal of the larger grains of hornblende. In the church at Fourth street and Lafayette place, erected in 1850, a little exfoliation has been produced by street-dust on the faces of some steps. In the Astor house, at Barclay street and Broadway, no decay was observed.

In the fine-grained granite from Concord, New Hampshire, employed in the building on the southeast corner of Twenty-third street and Sixth avenue, many of the blocks are set on edge, but the only change yet seen is that of discoloration by street-dust and iron oxide from the elevated railway.

The light-colored and fine-grained granite of Hallowell, Maine, has been used for the construction of the city prison, the "Halls of Justice" or "Tombs", in Center street. This stone consists of a white feldspar, which predominates, a grayish white quartz, which is abundant, and a considerable quantity of a silvery white mica, thoroughly intermixed. The rock possesses several properties—fineness of grain, homogeneity of structure, and freedom from iron, as shown by the color of the feldspar—likely to render it durable; the only unfavorable conditions are the predominance of feldspar and the laminated structure. The rock is a granitoid gneiss, with lamination often clearly marked; these markings at once show to the eye that most of the blocks are set, not on bed, but irregularly on edge.

The building is square and occupies an entire block. On a study of the weathering the south face was found to present an exfoliation to the depth of from one eighth to one-quarter of an inch at many points, up to the very summit of the building, particularly on the sides of the pillars at the southeast entrance, on the ashlar near the southwest gate, under and over the cornice and string-pieces. In some places the stone was loosened or peeled off in sheets of the area of a square foot. The west front presents much exfoliation all over the surface, though always thin; it seems to begin chiefly along and near the joints. In places fragments have separated from the corners of the blocks. The north front exhibits very little exfoliation; so also the east front, in a few small scattered spots.

a Usually about 1.

The exfoliation appears to be the result directly of the sun's heat, exerted most intensely on the southern and western sides of the building. An examination of the disintegrated material shows but little decomposition: a little kaolin may be distinguished in films, but the bulk of the feldspar, the weakest constituent, remains with bright facets, without change in color or luster. It is by no means characteristic of the "*maladie du granit*", first described by Dolomieu and later studied by Dr. T. Sterry Hunt; but here the action seems to be mainly and simply a disintegration of the grains, initiated by expansion under the sun's heat, during the summer, and developed by the expansion caused by frost during the winter. An architect of the city recently stated that he had built several large granite offices, and considered Quincy granite the most durable of all building material. He thought the weathering of granite would hardly amount to one thirty-second of an inch in a hundred years. According to that calculation many buildings might have a longer span than the thousand years spoken of by the professor.

However, it is a well known fact that the weathering of granite does not proceed by a merely superficial wear, which can be measured or limited by fractions of an inch, but by a deep insinuation along the lines of weakness, between grains, through cleavage-planes, and into latent fissures. Thus, long before the surface has become much corroded or removed, a deep disintegration has taken place, by which large fragments are ready for separation by frost from the edges and angles of a block. When directly exposed to the heat of the sun an additional agency of destruction is involved, and the stone is suddenly found ready to exfoliate, layer after layer, concentrically. As yet we have little to guide us in the estimation of durability in years, since the best known granite monuments are those which have been exposed to the exceptionally mild climate of Egypt; but even there some exfoliation has been noticed, *e. g.*, on the inner walls of the so-called Temple of the Sphynx.

In the cemeteries within the city and on Long island much granite is now used in slabs and monuments, but its introduction has been everywhere of too recent a date to afford any measure of its durability. Geikie remarks:

> Traces of decay in some of its feldspar crystals may be detected, yet in no case that I have seen is the decay of a polished granite surface sensibly apparent after exposure for fifteen or twenty years. Even the most durable granite will probably be far surpassed in permanence by the best of our siliceous sandstones. But as yet the data do not exist for making any satisfactory comparison between them.

GNEISS.—The oldest building in this city in which this material has been used appears to be that of Saint Matthew's Lutheran church, on the northeast corner of Broome and Elizabeth streets, erected in 1841. The stone is the micaceous gneiss, in part hornblendic, from excavations on the island, with trimmings, string-pieces, etc., of brownstone, the latter, as usual, being in a state of decay. On the west front the gneiss is in excellent condition, occurring in small blocks, mostly laid on the bedding plane. In the south front many of the quoins are set on edge and are much decayed along the joints, sometimes with splitting or exfoliation, fracture of corners, and irregular chipping out of the surface to the depth of one-half to one inch below the level of the projecting cement joints.

SERPENTINE.—This rock has been of limited application as a building material, but the evidence thus far is not in favor of its durability in a city. For example, the serpentine of West Galway, Ireland, called "Connemara marble", has been used both externally and internally in the new museum of Trinity college, Dublin, but "does not withstand the influence of a smoky or gaseous atmosphere". "Small tablets let into the outside wall of the museum have become tarnished within the space of ten years". In Hoboken this stone has been used to some extent for unimportant masonry, and shows in places discoloration and disintegration.

Other stones which may prove to be more durable, and as yet rarely exfoliate, have already, however, become more or less disfigured by discoloration. In the Nova Scotia and Ohio sandstones this is universally seen in black films, streaks, and blotches, of which both the cause and the means of removal are but little understood. The marbles used for house fronts also soon assume a dirty yellow hue. This is sometimes produced by the exudation of salts of iron, as in the walls of the new court-house; sometimes by the adherence of smoke and street-dust. It has been removed by occasional scraping of the whole surface of the building, as has already been done on the old court-house, the new cathedral at Fiftieth street, etc.

2.—EXTERNAL AGENCIES OF DESTRUCTION.

The external agencies which slowly but insidiously and steadily accomplish the disintegration and destruction of our building stones are of three classes, chemical, mechanical, and organic.

A. CHEMICAL AGENCIES.

These chiefly consist of acids which attack and dissolve every constituent of stone except quartz, but, with particular rapidity, any stone into which carbonates enter as chief constituents or as cementing materials. Thus the abundant solution of lime from the stone as well as the mortar of one of our marble buildings may be shown by catching some of the rain-water which trickles down its sides, and adding a few drops of ammonium oxalate, the solution becoming clouded by a milky-white precipitate of calcium oxalate. The following may be enumerated:

SULPHUR ACIDS, *i. e.*, SULPHUROUS AND SULPHURIC ACIDS.—Of these Dr. Angus Smith found in the rain of Manchester from 1.4 to 5.6 grains per gallon. The gases are daily absorbed into the atmosphere of a large city

from the consumption of illuminating gas, coal, and all kinds of fuel, the decomposition and oxidation of refuse organic matter and sewer gas, the residuary gases belched forth from the chimneys of dye works, chemical works, and numerous other manufactories, etc.

As coal seldom contains less than one-half per cent. of sulphur, and frequently one per cent. or more, every ton of coal when burned produces from 30 to 60 pounds of oil of vitriol. When one considers the enormous quantities of coal that are consumed in cities, and the correspondingly great quantities of this corrosive agent that are thus disseminated in the atmosphere, we would naturally expect to find appreciable evidence of its effects on building stones.(*a*)

These effects are likely to be most marked in a large city like London or New York, and on certain stones, *e. g.*, the earthy or oolitic limestones and marbles. In London they are revealed in the magnesian sulphate, which imparts a bitter taste, and even forms an efflorescent crust of white crystals upon the disintegrated portions of the Portland stone, and in the calcium sulphate, amounting to 3.4 to 4.6 per cent. in the decayed crust of the Caen stone. (*b*). Little limestone has yet been introduced into New York, and the durability of a variety in a village or small town elsewhere gives no measure of its fitness to resist the corrosive agencies in the atmosphere of our cities.

Carbonic acid.—This is a universal product of combustion, but is indeed derived from all the sources above mentioned, as well as from the respiration of millions of men and animals. Dr. Smith found the air of Manchester to contain 0.04 to 0.08 per cent. of carbonic acid, while that of the highlands of Scotland contained but 0.03 per cent. The researches of Daubrée, T. S. Hunt, and others, have shown the active action which this gas exerts in the corrosion of the feldspar of granites.

Nitric acid.—Traces of this acid have been commonly found in the atmosphere and falling rain, but most perceptibly during and after thunder storms. It has been suggested that "every flash of lightning not only generates nitric acid—which, in solution in the rain, acts on the marble—but also, by its inductive effects at a distance, produces chemical changes along the moist wall, which are at the present time beyond our means of estimating. (*c*)

So far as its formation is due to electrical agency, it probably increases during the summer; but it is also one of the products of oxidation of the gases arising from the decomposition of organic matter, ammonia, and nitrates, and from our numerous gas works.

Hydrochloric acid.—This corrosive agent Dr. Angus Smith found in the rain of Manchester, to the amount of 1.25 grains per gallon. It is derived from the fumes of bleaching works, chemical works, potteries, and many factories, and from vicinity to the sea.

Carbolic, hippuric, and many other organic acids derived from smoke, street-dust, sewer-vapors, etc., have not been hitherto recognized, but, in my opinion, are among the most constant and efficient agencies in the corrosion of the building stones of a city. Whether they are present in the atmosphere and falling rain is still a matter of conjecture, though I think it probable; but no series of analyses has yet been made to determine the exact constitution of the air and rain-water in our cities. However, there can be no doubt of their presence, possibly in the smoke and unconsumed carbon which attach themselves to our rougher stones (freestones, marbles, etc.), certainly in the street-dust, chiefly ground-up horse manure, which is blown against our buildings and remains attached to their surfaces, often to a considerable height above the street level. That the corrosion thus resulting is due not merely to mechanical friction, but mainly to chemical action, is shown by the fact that it is sometimes most active on a surface which is sheltered from the rain, and to which the crust of dust can adhere more persistently. For example, I have noticed that the vertical faces of the steps of Quincy granite beneath the portico of the church on the northwest corner of Fourth street and Lafayette place, perfectly sheltered from the rain, and but little exposed to the wind, have been sometimes covered with a film of street-dust beneath which the smooth-dressed surface of the granite is deeply corroded, peeling off to the touch of one's fingers in flakes from 2 to 5 millimeters in thickness. As to the foundations of buildings, these are exposed to the quiet action of the vegetable acids derived from the decomposition of plants and of the humus of the soil.

Oxygen.—This constituent of the atmosphere, especially in its more active form, *ozone*, attacks the sulphides (*e. g.*, the pyrite in the Vermont roofing slates and in the marble of Lee, Massachusetts, etc.), and, more slowly, the ferrous silicates in certain minerals (*e. g.*, the chlorite, biotite, hornblende, augite, etc., in our granites, gneisses, traps, etc.). The resulting oxygenation and hydration may be expected to produce expansion and a tendency to loosening of the constituents of a stone.

Ammonia is another product of animal life and decomposition, the fumes of factories, and atmospheric reactions, whose existence in the air and rain-water has been proved, and which must do its part in the disintegration of stone.

Common salt (sodium chloride) is constantly present in the atmosphere along the sea-board, and must affect the solubility of the cement of porous sandstones, etc. An English observer, however, considers that sea air is not injurious to stone, instancing Sandysfoot castle, near Weymouth, of which the stone is in perfect condition, although erected on the sea-shore and constantly washed by the spray since the time of Henry VIII. A comparison of the forms of decay of stone observed in the cemeteries within this city and in those nearer the ocean, *e. g.*, at New Utrecht, yielded no evidence of any results, attributable to this agency, in greater action at the latter locality.

a C. H. Porter: Paper on Building Stones, p. 24. Albany, 1868.
b J. Spiller, *Rep. Brit. Assoc. Adv. Sci.*, 1867.
c U. S. Commission, 1851.

B. MECHANICAL AGENCIES.

Some of these are probably, in our climate and conditions, the most efficient of all in the wear and disintegration of our building stones.

FROST.—The action of severe frost on stone must be usually one of the main causes of its rapid decay. Two elements are involved—the friability of the material and its power of absorption of moisture. The action may be expected to be most active where a material is repeatedly saturated with moisture, rain-water, or water derived from the thawing of snow and ice, and alternately frozen and thawed. The violence of the force resulting from the congelation of water within the pores of a stone may be understood from a recent estimate, that the effect produced by the freezing in a closed vessel, as it takes place very suddenly, resembles the blow of a hammer of 12 tons weight upon every square inch. However, the disintegration of our brownstones cannot be attributed entirely or mainly to this powerful agency, since the same decay is in progress in southern sea-ports where this brownstone has been used as a building stone; and I have been consulted by a correspondent at New Orleans in regard to the best means to arrest this decay in brownstone fronts there.

On other stones, *e. g.*, marble, this force may exert a very slow action; the experiments of Professor Joseph Henry and the calculations of Captain (now General) M. C. Meigs have shown the depth of exfoliation, after fifty alternations of freezing and thawing by artificial means, to amount to very nearly the ten-thousandth part of an inch. (*a*)

VARIATIONS IN TEMPERATURE.—The constant variations of temperature from day to day, and even from hour to hour, give rise to molecular motions which must affect the durability of the material of a building. Recent observations on the pendulum have shown that the Bunker Hill monument at Boston is scarcely for a moment in a state of rest, but is constantly warping and bending under the influence of the varying temperature of its different sides. (*b*)

The climate of New York must be far more trying than that of England, as the temperature may vary 120° or more in a single year, and even 70° in a single day, with many repetitions of similar extremes during the spring and fall, and sometimes during the winter months. The intensity of the direct rays of the sun, particularly in summer, and the frequent passing showers of cool rain-water falling upon the heated surfaces, are important elements in the attack upon the building stones.

The experiments of Colonel Totten, reported by Lieutenant William H. C. Bartlett in 1832, on the expansion and contraction of building stones by variations of temperature, yielded the following results, for the linear expansion, in fractions of an inch, of one inch of stone for 1° of Fahr.:

Granite bowlder at Buzzard's bay	0.000004825
Marble, Sing Sing, New York	0.000005668
Sandstone, Chatham, Connecticut	0.000009532

To apply these results to the case in question, let us suppose two coping stones, of 5 running feet each, to be laid in midsummer, when they have a temperature of 96° Fahr.; in winter their temperature may safely be assumed at zero, so that the total variation of temperature will be 96°.

The distance by which the ends of the stones would be separated would amount, for granite, to 0.027792 inch, giving a crack a little wider than the thickness of common pasteboard. For marble, this crack would have a width of 0.03264, nearly twice the thickness of common pasteboard; and for sandstone 0.054914, nearly three times the thickness of pasteboard. These cracks are not only distinctly visible, but they allow water to pass freely into the heart of the wall. The mischief does not stop here: by this constant motion, back and forth, in the coping, the cement, of whatever kind the joints might be made, would be crushed to powder, and in a short time be totally washed by the rains from its place, leaving the whole joint open.

WIND.—A gentle breeze dries out the moisture of a building stone and tends to preserve it, but a violent wind wears it away by dashing sand-grains, street-dust, ice particles, etc., against the face. The extreme of such action is illustrated by the vast erosion of the sandstones in the plateaus of Colorado, Arizona, etc., into tabular *mesas*, isolated pillars, and grotesquely-shaped hills, by the erosive force of sand-grains borne by the winds; in the window-panes of houses on Nantucket island, converted into ground-glass by flying sand; and in the artificial process of manufacture by the "sand-blast", carried on in our cities. A violent wind also forces the rain-water, with all the erosive acids it conveys, into the pores of stones, carries off the loosened grains from the surface, and so keeps fresh surfaces of stone exposed.

In this climate, buildings are most attacked by weathering agents on their north, northeast, and east fronts (the very reverse of the conditions prevailing in Great Britain), and, in this view, it is of course important to select stone of the greatest durability for the fronts into which the prevailing wind thus drives the rain, *i. e.*, those on the west sides of the avenues and the south sides of the cross-streets in New York city.

Again, the swaying of tall edifices by the wind, whose amount can only be appreciated by ascent of our church spires during a gale, must cause a continual motion, not only in the joints between the blocks, but among the grains of the stones themselves. Many of these have a certain degree of flexibility, it is true, and yet the play of the grains must gradually increase and a tendency to disintegration result.

RAIN.—The attack of rain on building stones depends upon its solvent action, partly due to the solvent agencies before mentioned, which it conveys, and upon its mechanical effect in the wear of pattering drops and streams

a Joseph Henry, *On the Mode of Testing Building Material.* *b* United States Commission, 1851.

trickling down the face of a building. In dry weather a stone is therefore less attacked, chiefly because the destructive acids cannot penetrate so deeply. The proportion of rainy days, and above all of frequent alternations of dry and rainy days, in any climate must exert a great influence on the durability of stone.

Professor Hull states:

In India, ancient temples formed of laterite—a modern deposit of gravel cemented by lime—are still in perfect preservation. Such examples, and many more which might be produced, all go to prove that even in regions subjected to very heavy periodical rains, provided the air be pure and free from acids, buildings of even friable and calcareous materials are capable of withstanding atmospheric disintegration for a lengthened period. Rains which fall at long intervals, though with tropical violence, do not act so injuriously on stone structures as those less violent but more frequent. *a*

CRYSTALLIZATION BY EFFLORESCENCE.—This effect, too, must largely depend upon the climatic conditions—alternations of dryness and moisture—to which reference has just been made. Examples of efflorescence of various salts, sulphates of magnesium, sodium, etc., are by no means uncommon in New York city and vicinity, though more frequently on brick than stone, walls covered with snow-white powdery coatings having been observed in basements of stores in South street, in cellars of residences in West Fifty-second street, etc. The expansion produced by such an exuding crust is likely, slowly but surely, to disintegrate and loosen scales and flakes from the surface of stone.

In an important investigation on this subject by Mr. Wentworth L. Scott, of London, the following results were obtained: (*b*)

Thirty-seven specimens of salt, collected from the surface of various building materials, were determined as follows:

Thirty-one, sulphate of sodium (and traces of other salts).

Three, mainly sulphate of sodium, and of magnesium and aluminium.

Two, mainly sulphate of sodium, with various phosphates and nitrates of sodium and calcium (never over 18 per cent. of the whole).

One, sulphates of sodium and potassium, with small amount of nitrates, and much sodium chloride.

With regard to the preventive means, * * * I cannot help denouncing the too free use of resinous, oleaginous, or tarry matters, as my own experiments have shown me that, at the end of time, the walls of a building treated with such substances would inflame the moment their temperature was raised to about 200°.

He suggests the prevention of upward percolation of moisture by a seam of asphalt, laid on every wall when 2 to 4 feet from ground, as used in St. James' hall, etc., London. He has cured the efflorescence of sulphate of sodium or magnesium by application of a weak solution of barium chloride.

Sulphate of ammonium has not an injurious effect until it meets with substances capable of converting it into the sodium salt.

Sulphurous acid or sulphite of ammonium exerts no harmful effect, but rather a preservative influence, occurring in too small quantity to produce efflorescence. The process of osmosis in building materials has been greatly exaggerated, and is probably very slow. It is important that mortars should be carefully chosen, that they may not contain efflorescent salts.

PRESSURE.—A large number of experiments have been carried on to determine the crushing weight of building stones, and the strength thereby indicated. However,

It is generally laid down that the compression to which a stone should be subjected in a structure should not exceed one-tenth of the crushing weight as found by experiment. Practically, however, the compression that comes upon a stone in any ordinary building is never [illegible] one-twentieth of the crushing weight. * * * The working stress allowed in practice upon ashlar blocks should not exceed one-twentieth of the crushing weight. *c*

Nevertheless it may be expected that when an ashlar block has become weakened by weathering, the rapidity of its disintegration and decay may be hastened by the superincumbent pressure, especially if unequally applied by the settling of the foundations.

FRICTION.—This agency of wear most commonly affects pavements, sidewalks, stoops, the facing of piers, etc. It may be derived from the impact of human feet, of wheels, or of the feet of animals; the handling of freight; the removal of dirt, snow, and ice; the flow of tidal currents; the blows of the waves of the bay and river, etc.

FIRE.—The fierce trials to which building materials of all kinds have been subjected, in the great fires in Chicago and in Boston, during the last decade, have shown that there are none, not even brick, which can withstand, in the form of thin walls, without warping or utter destruction, the tempest of flame evolved from the great magazines of combustibles gathered on every side in an American city.

It is a remarkable instance of the prevailing ignorance on this subject that there exist many varieties of sandstone (*e. g.*, the buff freestone from Amherst, Ohio, etc.), graywacke, and perhaps other rocks, which possess a fire proof character that enables them to resist a white heat, as the linings and hearths of iron furnaces, and which would seem to specially fit them for the ashlar of buildings desired to be fire proof, or at least the window sills, etc., of business buildings, storage houses, etc. It must be considered, however, that experiments are highly desirable to

a *Building and Ornamental Stones*, p. 313.

b On Salification, etc., *Jour. Soc. Arts*, 1860, Vol. IX, p. 274.

c *Notes on Building Construction*, p. 6.

determine the character of resistance of these and other stones, not only to the lateral application of flames or radiation of intense heat, when exposed in a building with a backing of brick, but also to the alternations, rapid and violent, of sudden expansion and contraction, produced by the sudden application of cold water from the streams of fire-engines upon the heated masonry. So far as present observations have gone, however, in regard to such sandstones, I see no necessity to reject the abundant materials supplied by nature, and will present additional reasons on a later page.

C. ORGANIC AGENCIES.

These are of a vegetable nature, in their attack upon the materials of building construction on land, and of animal nature in regard to the erosion of submarine walls.

VEGETABLE GROWTHS.—In regard to the influence of lichens on the durability of stone, very opposite views are held. On the one hand, it is acknowledged that, in the case of marbles and limestones, some lichens exercise a decidedly corrosive action, and Professor J. C. Draper, in a paper on the decay of stone and brick in New York city, maintains that the same "minute lichen, *Lepra antiquitatis*, grows with remarkable freedom on such hygroscopic rocks as the sandstones, as any one may satisfy himself on examining the houses on the cross, or east and west, streets of our city". (*a*)

So far as my observation has gone, lichens are markedly absent from the decayed stone-work of this city, and it is probable that the reference applies to some other form of vegetation. Thus they never occur in the churchyards of Trinity church and Saint Paul's chapel, though found abundantly in those of New Utrecht and Flatbush; *e. g.*, three species were distinguished upon a single tombstone (Rutgert Denyse, 1795) at New Utrecht. On their removal, the surface of the stone beneath is not found corroded, but only retains a fresh color.

In a report on the selection of the oolitic limestone used in the houses of parliament in London, the subject has been thus discussed by one of the commissioners:

> A question has frequently been raised with reference to the effect of vegetation on the surface of stone-work. By attentively examining the magnesian limestone buildings of this part of the country, it would appear that lichens exercise a sort of pernicious influence. At Bolsover castle, the keep of which seems to be constructed with magnesian limestone, similar to that of Steetley, wherever lichens have vegetated on the exterior of that edifice, decomposition has certainly taken place; and where they were then growing, upon removing them, we found that the surface of the stone, for about one-sixteenth of an inch in thickness, was reduced to a state of white powder. In such instances the lichen seems to possess some inherent power of chemically acting upon the stone; but whether the plant appropriates only the carbon to its own use and leaves the lime and magnesia, or whether it takes up the carbonate of lime and rejects the carbonate of magnesia, is a question of great interest, although it has not yet been investigated by a scientific observer. (*b*)

The opposite view, advocating their beneficial influence, is represented in the following quotations:

> Lichens are in many cases a protection from the weather, and tend to increase the durability of the stone. (*c*)

In the report on the selection of stone for the houses of parliament it is stated:

> Buildings situated in the country appear to possess a great advantage over those in populous and smoky towns, owing to lichens, with which they almost invariably become covered in such situations, and which, when firmly established over their entire surface, seem to exercise a protective influence against the ordinary causes of decomposition of the stone upon which they grow.

Many blocks of stone quarried at the time of the erection of St. Paul's, in London, but left in the quarries, and now covered by lichens, still retain their sharp edges and tool marks beneath the lichens, while those on the exposed fronts of the cathedral are now moldering away.

The sandstone of Tintern abbey (thirteenth century), in part laminated, is covered with gray and green lichens, and is, for the most part, in perfect condition. In Tisbury church (thirteenth and fourteenth centuries) the ashlar, constructed of calciferous limestone, is, where undecomposed, covered with lichens.

The exact action of the lichens needs investigation, and will doubtless be found to differ widely according to the species and the material on which they grow. Few of our buildings in this district are sufficiently old to present much growth of this kind.

There is another vegetable growth, however, that of the *conferva*, of which no notice seems to have been taken, but which flourish in damp weather all the year round, in New York and vicinity, upon shaded surfaces of our freestones, often coloring the vertical faces of the steps and the sides of stoops, and the lower portion of the ashlar, near the ground-line, and under the shadow of heavy copings and cornices, especially on the north shaded fronts of the houses on the south sides of the streets. Upon brownstone their eroding influence is shown in the common roughening of the dressed surfaces. Upon the Nova Scotia or Dorchester stone their action is apparently still more active, as shown in abundant instances on the walls and carved work throughout Central park, *e. g.*, the pillars of Albert quarry stone at the head of the steps at the end of the mall, where shaded surfaces are alternately seen colored green with *conferva*, and again bare and crumbling, at different seasons of the year, and have needed frequent redressing. It may also be remarked that the heavy growth of vines trained up over the fronts of houses, sometimes seen in this city, would be apt to favor such growths and the decay of soft freestones.

The well-known destructive agency of the roots of grasses and higher plants on the durability of masonry is fortunately not a danger to be considered in our American cities.

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a *The Manufacturer and Builder*, 1872, IV, 170.

b C. H. Smith: *Lithology, or Observations on Stone used for Building*, p. 26. 1845.

c *Notes on Build. Const.*, Part III, 10.

Boring mollusks, sponges, etc.—The serious danger of the attack of these forms of animal life may be illustrated by the following example:

A limestone from Creston, near Plymouth, England, was originally employed in the construction of the Plymouth breakwater, but the boring mollusks (*Pholas dactylus*) so perforated the stone, between high and low water, that it was thought necessary to replace the blocks by granite. (*a*)

Little masonry is yet exposed in our bay and along our river fronts to the attack of these enemies; but the cargoes of Italian marble sunk off the harbor, which have been found thoroughly perforated and honey-combed by such agency, *e. g.*, that of a steamer sunk in 1871, and the similar erosion of the gneiss of Westchester county, along the sound, by marine sponges, as pointed out by Mr. J. D. Hyatt, of the New York Microscopical Society, indicate the dangers which may be in store for the bases of the piers of the New York and Brooklyn bridge, and for the masonry which will be hereafter introduced into our piers and docks. Birds also serve as destructive agencies: the sparrows and other small birds by their droppings deposited in abundance on cornices and projecting moldings, and the pigeons, as in the London Exchange building, by pecking away the cement between the blocks of masonry.

3.—INTERNAL ELEMENTS OF DURABILITY.

The durability of a building stone depends upon three conditions, the chemical and mineralogical nature of its constituents, its physical structure, and the character and position of its exposed surfaces.

A. CHEMICAL COMPOSITION.

In this view the following conditions need consideration:

Solubility.—The presence of calcium carbonate, as in the more calcareous forms of our Westchester dolomitic marbles, and in the earthy limestones (*e. g.*, that from Indiana recently introduced), is likely to render such materials liable to rapid attack by acid vapors. On the other hand, in England pure dolomite is considered extremely durable as a building stone, as is shown, for example, in the Norman part of the Southwell church, in Yorkshire.

The hydrated form of ferric oxide which acts as the cement in all the Triassic sandstones (*e. g.*, the brownstone of New Jersey and Connecticut) is far more soluble, and so may be more easily removed, to the injury of the stone, than the anhydrous or less hydrated ferric oxide predominating in the cement of our Potsdam sandstone and many foreign sandstones, which seem likely on that account to be better resistants to disintegration. The sandstones whose cement is siliceous (*e. g.*, the Craigleith stone of Great Britain, and some varieties, almost quartzitic, of our own Potsdam sandstone in this state) are likely to be the most durable, and hereafter the most sought for, where durability is appreciated, in spite of their difficulty in working and dressing.

Tendency to oxidation, hydration, and decomposition.—In the case of a roofing slate, the presence of a sulphide (*e. g.*, marcasite, more decidedly than pyrite) is likely to be very injurious; in a granite or marble (*e. g.*, the marble of Lee, Massachusetts, in the new court-house, New York city) the results may be confined to the discoloration and less objectionable. Nevertheless there are abundant instances, which yet need investigation, in which the pyrite occurs in a highly-crystalline condition, even in roofing slates, by which it has been enabled to resist decomposition during centuries. If the pyrite is uniformly and minutely distributed in small quantity, its presence may be even advantageous: thus, the marbles of Berkshire county, Massachusetts, when first cut, are cold gray, but by long weathering acquire a tint of exquisite warmth and transparency. (*a*)

The biotite in many of our granites seems peculiarly liable to decomposition, and apparently to the weakening of the surrounding stone. The brown freestones of New Jersey and Connecticut contain everywhere minute scales of biotite, though in much less proportion than that of muscovite, and the freestones of New Brunswick contain similar scales of a chlorite; both minerals in a state of decomposition more or less advanced.

The orthoclase, which largely enters into the composition of the Triassic and the Carboniferous sandstones, and of all the granites in this market, is the feldspar of most ready decomposition. It is found, on microscopic examination of a brownstone or granite, in various stages of alteration, from a mere dimming of its cleavage planes to a cloudy or opaque mass of the usual structure, and finally to a siliceous shelly network, with its interstices filled with iron oxide. In this condition the mineral has lost all its strength and ability to resist either pressure or atmospheric attack, and a stone in which it prevails must have reached the last degree of disintegration and decay.

The albite, oligoclase, and other feldspars are much better resistants to decomposition, and their abundance in granite or sandstone may be an important element in their durability.

Inclosure of fluids and moisture.—The thorough drying of a stone before, and the preservation of this dryness after, its insertion into masonry are commonly recognized as important adjuncts to its durability. But the exact nature of the process of seasoning, and of the composition of the "quarry-sap" thus removed by thorough drying, have never been investigated. The "quarry-water" may contain little else than ordinary well-water, or may be a solution more or less nearly saturated, at the ordinary temperature, with carbonate of calcium, silica, double salts of calcium and magnesium, etc.; in the latter case, hardening results by the drying and an exact knowledge of its nature might throw important light on the best means for the artificial preservation of stone.

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a Gwilt's Encyc. Arch., p. 492. *a* Am. Arch. and Building News, 1881, X, 13, 17.

Again, water may exist in large quantity in chemical combination in the silicates (*e. g.*, chlorite, kaolin, etc.), or in the hydrated iron oxides which constitute the cement of a building stone. Many hydrates of ferric oxide are known to exist, and of these a considerable number occur in nature, in concentrated form, as ores.

We do not yet know how these or other hydrates of ferric oxide are isolated or mixed in their distribution through the brown sandstones. I have elsewhere (*a*) pointed out the probability that, to a large extent, the red cement of the sandstones of most recent or Tertiary age may be probably referred to limonite or limnite, *e. g.*, those found in eastern New Jersey and to the southward along the Atlantic and Gulf sandy plateau; that of the sandstones of the Mesozoic period to turgite and limonite (possibly in part göthite?), *e. g.*, the brownstones of New Jersey and Connecticut: and that of the bright red sandstones of the Carboniferous and older rocks to anhydrous ferric oxide, *e. g.*, the red freestones of New Brunswick and of Scotland, the red sandstones of Potsdam, New York, etc. However, these distinctions cannot be drawn sharply, and the subject awaits investigation. Changes in the degree of hydration are constantly going on in stones of this character, and the absorption of water may exert a force for expansion and disruption. In regard to the vast amount of water feebly locked up in combinations such as these, the query has been recently offered:

> We venture to suggest, as a subject for careful chemical analysis how far the existence of water or the elements of water, not as moisture, but as chemically combined with lime, magnesia, or other elements in a stone, may render it susceptible to the attacks of frost. (*b*)

The more recent results of microscopic lithology have also established the fact that certain minerals, especially the quartz, in very many of our most common building stones abound in small cavities partly or wholly filled with fluids, viz, water, brine, and liquid carbon dioxide. These cavities vary in size from microscopic minuteness up to a diameter of several millimeters, and are often very abundant, so that a fragment of quartz clouded by them may explode on the application of heat. The varieties of our building stones in which they are known to particularly abound are the following: Brownstone—New Jersey and Connecticut; freestone—Dorchester, New Brunswick; biotitic gneiss and fibrolitic gneiss—New York island and Westchester county; granite—Quincy, Massachusetts, Clark's island, Maine, Mount Beatty, Connecticut, Fitzwilliam, New Hampshire, Saint Lawrence county, New York, etc.

The question of the influence of these cavities on the durability of the rock, when exposed to frost or to the intense heat of the summer sun or to fire, is one that yet awaits investigation. The violent explosions which attend the exposure of granites to fire, as illustrated in the great fires of Chicago and Boston, may imply some connection, in part, with the sudden expansion and rupture of such inclosed fluid cavities; while the similar action of frost seems to be suggested by the interesting paper of Mr. W. E. Hidden on the fracture of quartz with liquid cavities in North Carolina. (*c*)

B. PHYSICAL STRUCTURE.

This varies widely in the crystalline and sedimentary rocks: but three conditions, common to both, will be first discussed, then two confined to the former class, and finally two confined to the latter.

SIZE, FORM, AND POSITION OF THE CONSTITUENT MINERALS.—It has been established that the resistance to compression—and it may be supposed in some degree the durability—of a finely-granular rock exceeds that of a coarsely-crystallized variety of the same. Dr. J. S. Newberry has also pointed out that "mica is soft and fissile, and hence is an element of weaknesss. Where it exists in any considerable quantity the stone is easily crushed and unfit for use".

The scales of mica in a laminated sandstone, *e. g.*, the common micaceous variety of brownstone, lie largely in the plane of lamination, and diminish the strength of the rock when pressure is applied in the direction of the latter plane, *e. g.*, on edge, on account of the feeble adherence between their surfaces and the rock in contact. So also when used as ashlar, the expansion caused by frost tends to produce the first separation along those planes.

However, both in a granite and in a freestone, it is probable that a moderate amount of mica—much more an abundance of a tough and fibrous mineral, like hornblende, augite, fibrolite, etc.—may serve as an excellent binding material, like hair in mortar, and add to the strength of the rock, if uniformly mixed, with little or no parallelism of planes. Peculiarities of crystallization in crystalline rocks or of arrangement of tabular flakes of minerals in sedimentary rocks may also produce a coincidence in the position of planes of stronger cleavage, *e. g.*, of feldspar in granites or in feldspathic sandstones, which will diminish both the strength and durability of a rock. The disintegration of the freestones of the Triassic age is favored by both these conditions—abundance of mica and parallel position of feldspar plates.

POROSITY.—Bischoff has thrown much light on the percolation of water through the interstices and fissures of rocks. Even in the densest crystalline rocks, as trap and basalt, spots of moisture can be discovered on freshly fractured surfaces, generally connected with minute fissures. In the loosely-cemented material of the freestones the percolation must be far more free.

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a On the Geological Action of the Humus Acids, *Proc. Am. Ass. Adv. Sci.*, 1878.

b *The Builder*, 1882.

c *Trans. N. Y. Acad. Sci.*, I, 1882.

The excessive porosity of a building stone thickens the layer of decomposition which can be reached by the acids of the atmosphere and of the rain, and also deepens the entrance of the frost and its work of disintegration. This is illustrated, in the case of brownstone, in numberless instances throughout New York city, in the sills and lintels of windows, the projecting string-courses of stone in brick buildings, the steps of stoops and sills of doors, etc., with their edges rounded, their material pitted, honey-combed, fretted, and furrowed by the ridges of projecting or eroded laminæ, or the whole mass of the stone worn away flush with the front of the house, *e. g.*, in the older brownstone houses of the district styled "Greenwich village", in the Eighth ward, and in the old streets on the east side of the city. Even, too, in houses less than ten years old, the flat ceilings of the porticos, surfaces which appear to be perfectly sheltered from the weather, are peeling away into successively-loosened layers, *e. g.*, in the houses on the west side of Fifth avenue, between Forty sixth and Fiftieth streets. In all these cases we plainly see the effect both of rain, and, above all, of water, derived from the thawing of the snow which is caught and rests upon the projecting ledge of stone, soaking down into the spongy mass below during the day, and again partially thrust out by the expansion of freezing during the night. With a light-colored stone an unusual and undesirable power of absorption is often indicated by its discoloration in streaks and circular patches. Several kinds of discoloration may be distinguished, all more or less dependent on the absorptive character of the stone. The one consists of a white calcareous efflorescence, very common in new masonry, in blotches spreading around the joints, and doubtless derived by permeation of the stone with solutions of calcium carbonate from the fresh mortar or cement. It appears to be usually of a temporary character, disappearing after a few years. This is sometimes seen in brownstone, but more frequently in the Ohio and the New Brunswick freestones: *e. g.*, in the fronts and stoops of most of the houses first built of that stone in Madison avenue above Fifty-fourth street, etc. Another form of discoloration is due merely to the street-dust and soot which are deposited upon the projections of a stone front. It results in long gray or blackish streaks, running down the front at either end of the window-sills and from below the line of projecting bands and cornices, and as a general blackish-gray discoloration of the surfaces of sheltered moldings of apertures, the pediments of porticos, etc.

The earlier stages of this discoloration may be easily studied in numerous instances among the older buildings constructed of light colored freestone, *e. g.*, in the houses on the northwest corner of Sixth avenue and Twenty-ninth street, and between Thirty-seventh and Thirty-eighth streets, and in the building on southeast corner of Christopher street and Greenwich avenue, etc.: the sloping window sills of the orphan asylum at Fifth avenue and Fifty-first street are thus blackened, while the vertical faces of the same stone in the façade are washed clean and uncolored.

A similar discoloration affects most of the varieties of white marble used in our city, *e. g.*, in several buildings on the north side of Murray street, between Church street and West Broadway; in the new court-house on Chambers street; the cornices, sills, and seams of the rusticated stone-work of the Union Dime Savings bank, at Sixth avenue and Thirty-second street.

Another form of discoloration, commonly associated with the preceding in the same light-colored freestones, presents black stains and streaks, whose material has not yet been identified, but apparently consists of manganese-oxide, probably derived from the decomposition of the feldspar and chlorite in the rock. This is of a more permanent and objectionable character, increasing both in extent and depth of color with the age of the masonry. Its progress is most rapid on stone surfaces exposed to the prevailing winds and rains, *i. e.*, the northeast. An illustration of this appears in the church on the corner of Fifty-seventh street and Madison avenue, whose faces fronting the south and west are entirely free from discoloration, while the spire, freely exposed above, is beginning to be tinted all around and from top to bottom.

Other forms of discoloration are shown in yellowish stains on the light freestones, certainly due to iron, and in films of confervous growth, which are green during rainy and damp weather, and become blackish-gray when dry.

Hardness and toughness.—Resistance to weathering does not necessarily depend upon hardness, since some soft rocks of peculiar composition (*e. g.*, some steatites, chlorite schists, etc.) are known to withstand atmospheric attack very well. However, a hard material of close and firm texture is, in those qualities, specially fitted at least to resist friction and artificial wear, as in stoops, pavements, sidewalks, and road metal, and the natural friction of rain drops, dripping rain-water, the blows of the surf, etc. The graywacke and blue stone of New York and Pennsylvania, is, in the form of flagging, unexcelled for paving, etc.; and no reason is apparent why its thicker beds should not be further applied as a material for ordinary construction. So far as yet introduced for this purpose, within a few years past, it preserves perfectly the arris in dressings, quoins, etc., without either chipping or discoloration.

Crystalline structure.—Experience has shown that the crystalline structure in a stone is a better resistant to atmospheric attack than the amorphous. The following statement is made concerning this characteristic in an oolitic limestone of England:

> The Steetley stone is remarkable for its light specific gravity, great power of absorption, and yet extremely durable; its resistance to atmospheric influences may be attributed to its beautifully sparkling crystalline structure, without having any dusty incoherent matter in its formation, the crystals being all well cemented together. (*a*)

a C. H. Smith, *op. cit.*, 32.

It is also well illustrated in New York city in the better class of crystalline building stones, *e. g.*, the granite buildings in Murray, Warren, and other of the older streets, the Astor house, etc., which are not yet perceptibly affected by the tooth of time. The same fact is generally true with the sedimentary rocks also, a crystalline limestone or good marble resisting erosion better than an earthy limestone. Only the oolitic varieties of the latter seem to possess, in that structure, an advantage over those that are entirely earthy or amorphous. The durability of a limestone like that of Indiana, recently introduced into this city, must depend upon these conditions. So, too, the highly-crystalline varieties of the Potsdam sandstone, in New York, Wisconsin, etc., abounding in glittering facets which the microscope reveals to be in part quartz crystals of exceeding minuteness, may be expected to have in that respect a greater likelihood of durability, if well cemented, than the ordinary variety made up of rounded grains.

Tension of the grains.—A crystalline building stone (*e. g.*, granite, gneiss, marble, etc.) is made up almost entirely of imperfect crystals of its constituent minerals (of calcite, in a marble—of quartz, feldspar, etc., in a granite) closely compacted together, originally with intense mutual pressure. Sometimes no cement intervenes, but any two grains remain in close contact at an impalpable invisible line. Such a condition must be sensitive to very slight influences, the surfaces of the grains in a building stone being alternately pressed still more tightly together or separated to disruption, *e. g.*, by variations of temperature, above all at the extremes of severe cold and frost, of burning sunshine, and of fire. A good illustration is found in those marbles which seem to contain no cement in their interstices, *e. g.*, the coarse Tuckahoe marble, which soon becomes seamed with cracks, as in the building on the corner of Thirty-second street and Broadway.

In England it has been found that—

> All varieties of Carrara marble have perishable qualities which ought to preclude them from being ever applied to external purposes in this country. After exposure to the weather for thirty or forty years, disintegration through its entire mass, but mostly on or near the surface, evidently takes place; after the lapse of about a century, more or less, according to the quality of the marble, the entire substance falls into a kind of sparkling sand. (*a*)
>
> Frequent changes of temperature also tend to destroy Carrara marble more rapidly than atmospheric influences; thus the mantel of a chimney-piece is invariably disintegrated long before any other part.

Contiguity of the grains.—The principle which obtains in the application of an artificial cement, such as glue, in the thinnest film, in order to gain the increased binding force, by the closest approach of the cemented surfaces, finds its analogy in the building stones. The thinner the films of the natural cement, and the closer the grains of the predominant minerals, the stronger and more durable the stone. One source of weakness in our brownstones lies in the separation of the rounded grains of quartz and feldspar by a superabundance of ocherous cement. Of course, the further separation produced by fissures, looseness of lamination, empty cavities and geodes, and excess of mica, all tend to deteriorate still further a weak building stone.

Homogeneity.—A great difference of the hardness, texture, solubility, etc., in the material of the grains of a rock and of their cement, or of the successive laminæ, renders the weathering unequal, roughens the surface, and increases the sensibility of the stone to the action of frost. So also softer patches, of more easily decomposed veins and layers in the stone, produce unequal weathering, hollows, furrows, and projecting ridges. Even a hard crystalline and otherwise durable stone may be materially weakened by these defects. Illustrations of this are found in the same varieties of the dolomitic marbles, with irregularly mixed constituents, from the old quarries at Kingsbridge, on New York island, and in Westchester county.

C. CHARACTER AND POSITION OF SURFACE.

The rough or polished condition of the surface of the stone, its inclination from a vertical plane, and the position in which it stands with reference to the sun and to the prevailing direction of the wind, all constitute important elements of its durability.

Smooth dressing or polish.—It is generally assumed, and rightly, in the climate of New York, that a smooth or polished surface tends to protect a stone by facilitating the rapid discharge of rain-water from its surface. The present condition of most of our smoothly-dressed granite fronts seems to confirm the general accuracy of this opinion. Nevertheless some anomalies occur. It has been observed in London that, in the modern buildings, decay progresses far more rapidly than in the ancient, and it has been queried whether this may not in some way be due to the application of machinery.

A series of observations by Professor Pfaff, of Erlingen, Germany, in reference to granite, syenite, etc., have shown, among other results, that the superficial loss in a century, by exposure to the weather, may amount, on unpolished granite, to 0.0076^{mm}, on polished granite to 0.0085^{mm}.

These conclusions in regard to the more rapid weathering of polished granite yet need confirmation by more extended observations in other localities. But an investigation is yet needed to determine whether the vibration of the surface of a stone, produced by the jar of the machinery employed in sawing or polishing, as well as the bruising produced by the friction of the sand, diamond saws, etc., and still more, the strain and pressure produced by the impact of the blows of chisel and hammer, in smooth and rough dressing, do not produce superficial changes of tension, minute fissures produced by the separation of surfaces of feeble adherence (*e. g.*, on smooth planes of

a Gwilt's *Encyc. of Arch.*, p. 491.

tabular flakes of feldspar, scales of mica, etc.), cracks in brittle minerals (*e. g.*, quartz), microscopic clefts along cleavage planes (*e. g.*, of the feldspars), slight disruption of grains from the adhering cement, etc. If these actions do occur in stone-working, and especially if they reach a sensible depth, as I believe, they may partly account for the anomalous loss of polish and rapid peeling away of successive layers from the surfaces of dressed granites and freestones. The very dressing, so agreeable to the eye, may actually present the surface of the weaker stones in the worst possible condition to resist atmospheric attack.

On the other hand, a roughness of the surface favors the deposition of street-dust, smoke, etc. In France—

> The beautiful marble sculptures of the park of Versailles will, within the next fifty years, become, through its means, unsightly and ugly masses of dirt, and eventually be irretrievably lost. Dr. Robart recently called attention to the fronts of the Bourbon and Mazarin palaces, that of the legislators, the mint, and others, which by this influence are hastening to decay, and even more rapidly in proportion as the ornamental carvings promote the deposition of dirt and dust. (*a*)

It has been shown that in New York these substances have been observed to exert a deleterious influence by chemical corrosion of the stone on which they rest. Being chiefly organic in material and absorbent of moisture they also furnish a suitable nidus for the growth of minute plants, *e. g.*, lichens, *confervæ*, mosses, etc., whose erosive action has been already mentioned. However, there is no doubt that under certain circumstances, not yet understood, a crust of dirt, smoke, and soot may act as a preservative to the stone, as observed by E. C. Robins and A. Billing, on St. Paul's and on Hanover chapel, London, on the church of St. John's, in Southwark, etc.; the same is true also of at least some of the vegetable growths—certain lichens which flourish in the dusty deposits.

Inclination and position.—Sufficient reference has already been made to the influence of these conditions in many ways on the durability of stone. The illustrations are without number throughout the older streets of our city, in the decayed state of those surfaces of stone which are horizontal, and on which rain-water, slush, snow, and ice may rest; of those on the south side of cross-streets, and the west side of the avenues running north and south, which are exposed to the driving rain of northeast gales, etc. Thus, in the towers of the church on the northwest corner of Clinton and Pacific streets, Brooklyn, the brownstone on its front, which faces the east, is peeling off in patches in many places, while the south face of the towers remains apparently unattacked.

Again, on surfaces which are liable to be water-soaked, but which may be sheltered from the sun and wind, the moisture does not quickly dry out, and here especially the decay may be very rapid. The soffits of arches and lintels, the shady sides of window-jambs, and the shady parts of carvings, etc., are among the first portions of a building to decay. From this cause, or from the leaking of a rain-water leader, the surface of a whole pilaster may peel off, as in the building on the southeast corner of Eighteenth street and Fourth avenue, New York.

Method of pointing of masonry.—The admitted energetic agencies of decay—frost, solution, hydration, etc.—have been largely favored by the imperfect and hasty construction of the masonry throughout the city, its joints when new often admitting a trowel. A cement-mortar of poor quality is largely employed, and, soon dropping out, the joints are often allowed to remain open for years. The atmospheric attack is thus made, as it were in flank, directly through the exposed edges of the outer laminæ of the stone, and the decay rapidly affects the stone to a considerable depth, several inches in many cases, and even throughout the entire block, although the exfoliation may appear superficial.

Erection on edge of lamination.—Instances are very rare in this city where the stone has been laid "on its bed", with a deliberate regard to its durability: *e. g.*, a few houses on Fifth avenue above Fifty-first street, the new wings of the Astor library, etc. On the other hand, from mere convenience in construction, many buildings, especially of our older churches, are fortunately so constructed, the blocks having been small and square and conveniently so laid. In some instances (*e. g.*, the church on the southeast corner of Thirty-fifth street and Fifth avenue) blocks occur in both positions and in both are affected by incipient decay; in others (*e. g.*, the church on southwest corner of Twenty-first street and Fifth avenue) the blocks, although all on bed, are often deeply decayed. In the old city hall, erected in 1812, the north face, although on the side usually least affected by decay, presents the brownstone of its ashlar set on edge and exfoliating in entire sheets, often traversed by fissures across the lamination, parallel to the joints. Notwithstanding these warnings, most of our newest edifices exhibit the same faulty construction: *e. g.*, the sandstone (from Massachusetts) in the trimmings and even partly in the pillars of the Union League Club building, on Fifth avenue, the fine new residences in the upper part of Madison avenue, the trimmings etc., in the huge new buildings for "flats" and business offices throughout the city, often nine to eleven or more stories in height, in whose walls the crushing force exerted upon this soft stone must be excessive.

Exposure to the sun.—Again, subjection to wide differences of temperature on different faces, *e. g.*, those produced by the burning heat of our summer sun on the western faces of buildings, renders the stone liable to crack from unequal contraction and expansion, and produces, on a laminated rock, separation along the planes of lamination, and, on a compact rock, an exfoliation in concentric crusts allied to that of common occurrence in nature on outcrops or bowlders of granite and trap. The former is abundantly illustrated in the marked decay and splitting observed on the western faces of the tombstones in Trinity church yard, the cemetery at New Utrecht, etc., described beyond. The ashlar at the base of the steeple of the church at Thirty-seventh street and Fifth avenue is beginning to decay on the south side, but not on the north or east sides (the west side not being visible). Other examples are

(*a*) *Manufacturer and Builder*, 1871, III, p. 150.

seen on the brownstone stoops of our cross (east and west) streets, where the western face of the dark stone is rapidly disintegrated and exfoliated, while the eastern face remains much longer in perfect condition. The stone balusters of the balustrades of balconies and the sides of high stoops are, from their slender form, peculiarly sensitive; they disintegrate and exfoliate rapidly on their sun-exposed sides, and become split, ragged, and reduced within five years to a wretched condition, especially when the bedding plane is exposed to the sun. Little rule is observed by stone-cutter or builder in regard to the position of planes of bedding in work of such delicate character as the stone rails, balusters, and posts of stoops and balconies, the planes lying and facing in every direction, sometimes uniform in a particular stoop, sometimes differing—vertical, horizontal, or even sometimes oblique, and directed to all points of the compass—though in general the planes are vertical in the balusters of a stoop and stand either parallel or perpendicular toward the front of the building. The decay is much more rapid in the coarse brownstone, though apparent on the light-colored freestones, and affects the western side of balusters on the cross-streets and the southern side on the avenues. It seems to be somewhat delayed wherever the edges of the layers happen to face toward the sun, *i. e.*, to the west on cross-streets and to the south on avenues, in New York city.

In general it may be stated that all the influences of driving winds, acid vapors, pelting rains, burning sun, etc., are less destructive by far than the quiet action of rain-water or thawing snow dripping and soaking down continuously from any projection or hollow in which water or snow may lodge. A good illustration is found in the synagogue on the southeast corner of Sixty third street and Lexington avenue, in the fresh, unaltered condition of all its vertical faces of light freestone, and the extensive discoloration which has attacked the face of the pediment of its front portico from water soaking through its roof, and the discolored streaks which run down the inner corners of its towers.

4.—METHODS OF TRIAL.

The methods now in vogue are to a large extent so superficial and empirical, so unsatisfactorily confirmed by the practical results attained, as to have elicited from many an opinion akin to that expressed by a member of the London Society of Arts. His impression was, and it was borne out by the opinions of many practical men, "that when a stone was once out of the quarry it was almost impossible to say whether it was a good stone or a bad one". It has long been recognized that there are two ways in which we can form a judgment of the durability of a building stone, which may be distinguished as the natural and the artificial.

A. NATURAL METHODS.

These must always take the precedence wherever they can be used in any locality, because they refer, first, to the exact agencies concerned in the atmospheric attack upon a stone, and secondly, to long periods of time far beyond the reach of artificial experiment.

A memorable investigation, in which the main dependence was rested apparently upon this class of methods, was that instituted by the British parliament in the royal commission appointed in 1837 for the selection of the stone to be used in the houses of parliament. This commission consisted of four persons: the architect, Sir Charles Barry; two geologists, Sir Henry De La Beche and Dr. William Smith; and Mr. C. H. Smith, a practical man, well acquainted with the working of stone, occasionally assisted by Dr. Buckland and Professor Phillips, and, in the chemical department, by Professors Daniell and Wheatstone. From the study of the outcrops in neighboring quarries and the weathering in several old buildings in Yorkshire, the commission recommended the use of the stone from the Norfal quarries, North Anston, ten miles east of Sheffield, and were discharged. The execution of this recommendation was put in incompetent and irresponsible hands, without government superintendence. Consequently the stone of the Norfal quarries having been adjudged too small for the purpose, and also those of a neighboring quarry, resort was finally had to a stone not covered by the report of the commission, and of this the houses of parliament were mainly erected in 1840. It proved of such inferior character that the decay, immediately setting in, attracted attention even in 1845, and has since led to extensive and costly efforts for the purpose of repair and preservation.

Examination of quarry-outcrops.—Much information of the highest value may be obtained, especially in the northern United States, where the results of ancient decomposition have been planed off by glacial action, from a study of the old natural exposures of a stone to the atmosphere at or near the quarry from which it was taken, with allowance for the conditions which may there prevail at present, or which probably existed in pre-glacial time. However, it has been pointed out that "the length of time they have been exposed, and the changes of actions to which they may have been subjected, during, perhaps, long geological periods, are unknown; and since different quarries may not have been exposed to the same action, they do not always afford definite data for reliable comparative estimates of durability, except where different specimens occur in the same quarry".(*a*) Within the district allotted to this report only three building stones are found in place: The trap of the Palisades and of Staten island, whose exposed surfaces are almost always smooth, and whose crust of disintegration, rarely reaching a half inch in thickness, implies a power of excellent resistance to atmospheric attack; the gneiss of New York and Long islands, which often becomes deeply discolored along some planes, but even then, in its common siliceous variety, retains most of its toughness and strength; and the dolomitic marbles of the old quarries of Kingsbridge

a Report of Commission to Test Marbles for the Extension of the United States Capitol, p. 589, 1851.

and Morrisania, no longer worked, and of Westchester county, in which a wide variation is shown on the exposures, some surfaces being disintegrated to a pulverulent mass or loose sand, while others remain firm and hard.

EXAMINATION OF OLD MASONRY.—A study of the surfaces of old buildings, which have been exposed to atmospheric influences for years or centuries, is one of the best sources of reliable information concerning the durability of stone, and frequent references to such observations have already been made in this report; unfortunately no buildings of great antiquity have resisted the iconoclasm of our period and remain for study. Following, however, the example of Professor Geikie, of Great Britain, in his study of a grave yard of Edinburgh, I have made some studies in those of New York and vicinity. It may be remarked that the varieties of stone used in cemeteries for the dead are usually for the most part identical with the building material employed in the houses of the living at the same period. Nor could any method be devised for testing so thoroughly, by natural means, the elements of durability in any stone as that by which, in the form of a tombstone, it is inserted partly in the moist earth, entirely exposed above to the winds, rain, and sun on every side, with its bedding lamination standing on edge, and its surface smoothed and polished and sharply incised with inscriptions, carvings, and dates, by which to detect and measure the character and extent of its decay.

The present edifice of Trinity church was constructed during the years 1841–'46, the first building having been erected on that site in 1696). Saint Paul's chapel was erected in 1766, and, although this structure is older than that of Trinity, its cemetery is much more recent in its origin.

Trinity church yard, New York city.—A variety of materials is found in the tombstones of this cemetery, one of the oldest inclosed in the city. The observations made on the present condition of the stones have been grouped together according to the material, disregarding as carefully as possible all stones which showed evidences of repair and recutting. Most of the stones are erect, and stand with their planes in the meridian, *i. e.*, their inscribed faces fronting the east.

Red sandstone, compact, hard, and fine-grained, apparently identical with that of the church building, and forming the largely predominating material for the stones: Tomb of Matthew Daniel (1820), west side split off, but general condition otherwise good, and inscriptions sharp; also, several tombstones in vicinity in same condition, with more or less splitting along lamination on their western faces, *e. g.*, those of John Child (1808), John Wilson (1805), Peter B. Ustick (1791), Jane Slidell (1770), John Waddell (1762), Joseph Penn (1763), Charles Burleigh (1757), and many others; tombstone of children of John and Mary Bard (1796), much eroded, and splitting on both sides. Two of the oldest stones, those of Jeremiah Reeling (1722) and Richard Churcher (1681), are in very fair condition, the inscriptions being sharp, and only a slight tendency to splitting beginning to show on the west side of the top of the stone.

Graywacke or blue-stone, probably from the Catskills or central New York: Tombstone of Remington Stephenson (1739), in excellent condition, but west side beginning to decay; that of Mary Corrin (1739), perfect on both sides; inscriptions sharp on both stones.

Black slate, probably imported: Tombstone of John Daley (1774), in very good condition, only a slight decay roughening the west side; that of Anne Churcher (1691), both faces and edges perfect and the inscriptions sharp.

Gray slate, perhaps from the Catskills: Tombstone of George Carpender (1730), inscription sharp, slight erosion on west face.

Green hydromicaceous schist, probably from western part of Connecticut or Massachusetts: Tombstone of Joshua Amy (1742), in excellent condition, only the west face being slightly worn.

White oolitic limestone, fossiliferous, probably imported from England: Tombstone of John and James Searle (1736), in excellent condition.

Fine white marble, apparently from Carrara, Italy: Inscription and date obliterated, full of minute cracks on both faces.

White marble, probably from western Massachusetts: Tombstone of Lars Nannestad (1807), and that of Alexander Hamilton (1804), both in fair condition, but worn on the north face.

Saint Paul's church yard.—One variety of fine grained sandstone predominates, dating from 1813 back to 1768. The finest-grained and most compact are often in perfect condition (J. L., 1768), but many coarser or more laminated stones, and sometimes fine and compact stones, are very badly split, and show exfoliation near the ground (A. Van B., 1813), sometimes with fissures across the stone (J. A., 1813). The splitting begins, as usual, near the west face and near the edges.

As to marble, the stones here date from 1851 back to 1798, and consist of a coarse white marble. It weathers grayish white, and becomes roughened. Only a small proportion of the stones are split. About one tenth have their inscriptions entirely obliterated, and this fact, due doubtless to the acid rain-waters of the city, was not observed in the suburban cemeteries; in one case (A. W., 1851) it has been largely affected in a little over thirty years.

The old Dutch cemetery at New Utrecht, Long island.—At this little village, which lies on the southern outskirts of Brooklyn, most of the tombstones are erect, in good condition, and face the east. The materials used are the following:

Fine-grained sandstone, of a warm red to reddish-brown color, resembling the stone of Little Falls, New Jersey. As a rule the stones of this kind are in excellent condition, especially in proportion to their fineness of grain, and

universally preserve the sharpness of their inscriptions. Their dates observed range from 1812 back to 1743, and out of twenty-five noted the following may be referred to: Jacques Denyse (1811), very fine-grained, inscriptions and tool marks perfect; John Van Duyne (1801), in perfect condition; Rutgert Denyse (1795), very fine-grained stone, inscription remarkably perfect, even to the finest flourishes: Jacques Denyse (1791), in good condition, a small fragment lost from top edge; Jacobus L. Lefferts (1785), very fine grained, and in perfect condition; Abraham Duryee (1743), stone perfectly preserved.

Graywacke, light gray, and thinly laminated: S. Barre (1852), stone split throughout, especially on the west face.

Blue marble: Catharine Groenendyke (1797), stone in excellent condition, hard and smooth on the west face, but slightly roughened and pulverulent on the east face.

Mottled black and white marble: Mercy Grenendyck (1794) and Nicholas Grenendyck (1795), in perfect condition in both form and sharpness of inscription, the west undressed face being hard, but the surface of the east face, top, and sides being somewhat roughened and pulverulent.

Red laminated sandstone, probably from New Jersey: W. W. Barre (1854), the east face in perfect condition, but the top and west face beginning to split; Cornelius Van Brunt (1850), the faces in good condition, but a fissure in the lamination behind the east face; Ann Schenck (1824), stone split along the lamination next the west face, and also with a vertical fissure across the lamination of the stone near and parallel to the north edge; William Barre (1826), and Rebecca Johnson (1821), a stone with alternating red and gray laminæ (like that used in the Flatbush cemetery), thoroughly split up throughout, along the lamination, and with fragments lost from the top.

White marble, rather fine grained, and for the most part from Vermont, stones dated from 1847 back to 1828, with usually their inscriptions perfect (for example, the stone of Thomas Clark, 1831), their west faces in good condition, but their tops, sides, and east faces more or less roughened and pulverulent; the stone of J. Lefferts (1828), is in good condition except on the west face, which is much split, apparently by the sun.

Granite from Quincy, Massachusetts, and Aberdeen, Scotland, in a few stones dating only from 1876 back to 1856, and of course in perfect condition. The varieties of stone have been arranged above in about the order in which they seem to have come into general use. In regard to their durability it may be stated in general:

1. The fine-grained red sandstone, probably from Little Falls, New Jersey, has presented a remarkable resistance to weathering, always proportioned to its fineness of texture, generally in excellent condition after a period of more than a century.

2. The laminated sandstone, brought later into use, has been a poor material, yielding miserably, apparently to the heat of the sun, in less than a half century.

3. All the marbles used have resisted the sun in almost every case, but show by the roughened, pulverulent condition of their sides and eastern faces that their decomposition is slow but gradual, and only a question of sufficient though perhaps long time.

A point of difference between the stones of this cemetery, in an open country village on the outskirts of Brooklyn, and those of Trinity church-yard, in New York city, is shown in the abundance of lichens which are found in the former. Three varieties seem to occur: one, a bright green, confined in its growth to the top of the stones; another, of orange color, scattered over the upper part of the west face, exposed to the afternoon sunshine, and rarely seen on the east face; and another of light green color, abounding as a crust over the east face. No particular effect of corrosion by these growths was noticed, either upon sandstone or marble; on their removal the surface beneath was found to be fresh, and had apparently been only protected from weathering.

Flatbush cemetery.—In the old cemetery of the village of Flatbush, Long Island, on the northeastern outskirts of Brooklyn, the tombstones are nearly all vertical, and face the east. White marble predominates largely, but the oldest stones consist of sandstone.

Red sandstone, usually very fine grained and compact, and apparently the variety from Little Falls, New Jersey. The stones vary in date from 1804 back to 1754: Rebecca Suydam (1797), and Marrytie Ditmarse (1797), both faces of these stones in excellent condition; Hylletie Martens (1779), a light reddish-gray stone, in good condition, only the top being a little roughened; Abraham Lott (1754), the inscription perfect, and only a few fragments chipped from the top.

Red laminated sandstone, often very fine grained, largely made up of two materials, reddish-brown and light reddish-gray, in thin alternations from one-half to 1 inch thick. The stones vary in date from 1822 back to 1754: Maria Allen (1820), with sharp inscription, but many fissures in the lamination; Peter Neetus (1820), the stone in excellent condition, covered with sections of long cylindrical markings, perhaps fucoidal; Leffert Lefferts (1800), the stone traversed by fissures along the lamination, and also vertically across it in lines parallel to the edges and about an inch from the edge; Adriantie Lefferts (1761), like the preceding; Gelijam Cornel (1754), decidedly laminated in structure, but in excellent condition.

Tremolitic white dolomite marble, perhaps from the old quarries of New York and Westchester counties, fine-grained to quite coarse in texture, and often sprinkled with grains and flakes of tremolite, sometimes several inches in length. The stones vary in date as follows: E. Aldworth (1851), the stone facing westward, and with minute fissures abounding over the top and the southern edge; A. Lloyd (1847), the stone in good condition, still retaining

most of its polished surface, even on the tremolite; J. F. Neefus (1847), surface of stone rough and pulverulent, so that the rough, gray appearance usually distinguishes stones of this material from some distance; Mary Van Sicklen (1832), the top and west face roughened one-third of the way down, the remainder being much less roughened; W. Riley (1811), smooth for a height of about a foot from the ground, and roughened above.

Fine white marble, probably of Carrara, the stones varying in date from 1859 to 1801; E. Duclois (1836), somewhat rough and pulverulent all over the surface; N. R. Cowenhoven (1809) and J. Vanderbilt (1801), both horizontal tablets, more or less blackened in spots by a minute lichen (probably the *Lepra antiquitatis*), etc.

Fine white marble, sometimes with gray streaks, probably from Vermont: the stones are of recent date, from 1855 to 1730: Charity Van der Veer (1836), the entire surface of the stone pulverulent, rubbing easily off into fine sand; Femetie and Peter Stryker (1730), roughened down to a foot from the ground, where the polish remains.

The lichens abound here also on the tops of the stones, but have been mostly cleaned off their faces. The same general conclusions may be here deduced, in regard to their durability, as in the similar varieties observed at New Utrecht. It is a curious circumstance, in all these cemeteries, that the stones display no exfoliation or decay near the ground, the polished surface often remaining perfect; above, the action of the sun on the western faces, and of northeast storms on the eastern faces, are apparent as usual.

B. ARTIFICIAL METHODS.

The various text-books on building-construction describe in detail many methods of trial of building stone; *e. g.*, of solubility in acids; of absorptive power, by soaking in water and determination of increase of weight; of power to resist the expansion due to frost, by actual freezing, or by saturation in saturated solution of sodium-sulphate (Brard's method); of strength to resist crushing, bending, or tension, by the application of pressure or force in various ways, etc.

It is unnecessary to make any reference here to these descriptions, except in regard to their antique and unsatisfactory character, and to the apparent ignorance of the appliances now within the reach of students of the modern science of lithology, which can readily be used to reveal the true nature of a building stone and the elements of its durability, *e. g.*, the study of its surface under the microscope, or of slices ground so thin as to be transparent, or of its individual mineralogical constituents separated by means of their difference in specific gravity, or by means of the almost endless resources of micro-chemistry. The careful and well digested circular of the department of building stones, issued by the late curator of the National Museum, Mr. George W. Hawes, whose recent decease has been universally deplored as a great loss to science and to the work now in progress in this field, has given a suggestion of the wide departure from the old and incomplete methods which is at last called for, in order to advance our knowledge of the proper application and practical use of building stones, under the light of modern discovery.

One important method, long in use, is the determination of the absorptive powers of a stone. A granite which absorbs water to over half of 1 per cent. of its weight is open to the suspicion of doubtful durability. Similar caution needs to be observed in the choice of freestones in our own climate.

Any sandstone weighing less than 130 pounds per cubic foot, absorbing more than 5 per cent. of its weight of water in twenty-four hours, and effervescing anything but feebly with acid, is likely to be a second-class stone, as regards durability, where there is frost or much acid in the air.

It is here pertinent to refer briefly to some significant results obtained by Professor John C. Draper, of this city, in experiments on two of our most common building stones, in comparison with brick.

Fragments of each of the materials were soaked in a saturated solution of sodium sulphate for four hours, then allowed to dry and crystallize for twenty hours, then freed from loosened material by washing off by means of a fine jet of water from a wash-bottle. This operation was repeated eight times, *i. e.*, eight days, with the following results, the first column of figures representing the loss of substance, by weight, in 10,000 parts:

	Loss.	Ratio.
Nova Scotia stone	441	18
Brownstone	191	8
Red brick	74	3
White brick	24	1

As Professor Draper has pointed out, these results only tend to show that frost is not the main agent of the initial disintegration in the climate of New York, since it is not the Nova Scotia stone, but the brownstone, which suffers the most severely and rapidly from decay.

A quicker method employed was to heat the specimens to a temperature of about 600° Fahr., and quench them, while hot, in cold water. This method of trial yielded the following comparative results:

	Loss.	Ratio.
Nova Scotia stone	597	14
Brownstone	202	5
Red brick	82	2
White brick	43	1

These results appear very significant, especially in relation to the power of brick and stone to resist the destroying action of great conflagrations.

Again, to determine the extent of the action of acid vapors in the air upon the building stone, fragments of the same materials were digested in dilute acids, and the following results were obtained:

	Loss.	Ratio
Brownstone	216	30
Nova Scotia stone	66	9
Red brick	33	5
White brick	7	1

On this subject Professor Draper remarks:

From this it would appear that the reason the brownstone disintegrates so rapidly in our city is its greater susceptibility to the action of the acid products of organic decomposition and combustion; where the cementing material is dissolved or weakened, and pores and fissures in the rock being opened, it is less liable to resist the attack of frost. The Nova Scotia stone, on the contrary, is a more friable material than the brownstone; yet, being less acted upon by the acid waters, it resists the process of decay better.

On the other hand, Dr. Page has obtained the following results, by Brard's process, on 1-inch cubes of several building stones used in this city, which do not confirm Professor Draper's results:

Variety.	Locality.	Specific gravity.	Loss in grains.
Coarse dolomitic marble	Pleasantville, New York	2.859	0.91
Close-grained sandstone	Little Falls, New Jersey	2.482	0.62
Coarse-grained sandstone	Connecticut		14.36
Fine-grained sandstone	Connecticut	2.583	24.93
Coarse-grained sandstone	Nova Scotia	2.518	2.16
Light dove-colored sandstone	Seneca, Ohio	2.456	1.78
Hard brick		2.294	1.07
Soft brick		2.211	16.46

Many experiments have been made to determine the crushing strength of building stones, an element which probably bears some relationship, at least in a general way—exactly what, it has never been determined—to their durability. The results in regard to the building stones used in New York, according to various authorities, are given in table on pages 330–335. They have been collected from various publications, mainly the reports of 1874 and 1875, by General Q. A. Gillmore, on the compressive strength, specific gravity, and ratio of absorption of the building stones of the United States, and a report of the results (communicated to me by Mr. F. R. Collingwood, an engineer of the New York and Brooklyn bridge) of the trials by Mr. Probasco, of the dock department of this city, on the stones employed in the bridge. A point yet needing investigation, but apparently as yet disregarded, is whether the crushing strength of a stone, as determined on the bed, may be affected, possibly diminished, by the reversal of its original position; a fact probably of common occurrence, since the original top of a block is rarely marked.

Other experiments have been made, too limited and imperfect for quotation here, such as those by Professor Joseph Henry and the United States commission in 1851, and by Professor Walter R. Johnson in 1852, to determine the amount of material thrown off from American marbles, etc., by repeated freezing and thawing, etc.

In this connection we may refer to the experiments made by Dr. Hiram A. Cutting, of Vermont, on a series of American sandstones, in regard to specific gravity, weight, absorptive power, and resistance to fire. The results on varieties like those used in New York city are quoted in the following table (*The Weekly Underwriter*, 1880, Vol. XXII, p. 288):

Local name.	Locality.	Specific gravity.	Weight of one cubic foot.	Ratio of absorption.	Heated at 600° F.	Heated at 800° F.	Heated at 900° F.	Heated at 1000° F.	Heated at higher temperatures.
			Pounds.						
Freestone	Portland, Connecticut	2.380	148.7	1 + 27	Not injured	Not injured	Friable	Tender	Ruined.
Freestone	North of England	2.168	135.5	1 + 27	do	do	Cracks badly	Spoiled	
Montrose stone	Ulster county, New York	2.661	166.3	1 + 314	do	do	Not injured	Slight injury	Stands well.
Freestone	Belleville, New Jersey	2.350	146.8	1 + 27	do	do	Cracks	Friable	
Freestone	Nova Scotia	2.424	151.5	1 + 240	do	do	do	do	
Carboniferous sandstone	Br. Philips, Nova Scotia	2.353	147.0	1 + 19	do	do	Crumbles	Cracks and crumbles.	
Freestone	Dorchester, New Brunswick	2.363	147.7	1 + 26	do	Cracks	Cracks and crumbles.	do	
Berlin stone	Cleveland, Ohio	2.210	*138.1	1 + 22	do	Not injured	Slight cracks		Stands well.
Berea stone	Berea, Ohio	2.254	140.8	1 + 20	do	do	do	Crumbles	Do.
Amherst stone	Amherst, Ohio	2.200	*137.5	1 + 18	do	do	Changes color	Friable	Do.
Brownstone	Hummelstown, Pennsylvania	2.346	146.6	1 + 28	do	do	Cracks	Crumbles	
Potsdam sandstone	Beauharnois, Quebec	2.512	157.0	1 + 38	do	do	do	do	

* It is claimed that these figures understate the true weight, which is said to approximate 155 pounds.

5.—MEANS OF PROTECTION AND PRESERVATION.

We have next to consider, first, the natural principles, very commonly neglected, which should be considered in the construction of stone buildings in the climate of New York city, and, secondly, the artificial means which may yet be applied for the preservation of our crumbling edifices.

A. NATURAL PRINCIPLES OF CONSTRUCTION.

These may be simply divided as follows:

SELECTION.—British architects have sometimes become so discouraged at their ill-success in fighting the elements on the safety of the materials they employ in construction, that the recommendation has been made to discard the soft freestones commonly in use, and resort entirely to the "igneous rocks", so called, in polished blocks, *e. g.*, granite, basalt, serpentine, etc.

Mr. C. H. Smith, one of the commissioners on the houses of parliament, makes a statement (*a*) which is as applicable in the latitude of New York as in that of London.

The chief cause of failure in stone work used rested with the architects. A young architect would like to make as much display as he could for his employer. To make a great show, he used a cheap description of stone. It was generally put into the contract that the best materials only should be used, but it might be a question whether young architects, or even old practitioners, knew what was really good stone, and they would not apply to those who did. The builder naturally preferred a soft stone, because it was easily worked and yielded him the largest profit.

One of the most important principles in the selection of stones for our climate is that "porous stones should not be used for the copings, parapets, window sills, weather fest of cornices, plinths, strings, or other parts of a building where water may lodge". Such rocks when used should be carefully tested for absorptive power; a granite which absorbs water to over one half of 1 per cent. of its weight, is open to the suspicion of doubtful durability. Similar caution needs to be observed in the choice of freestones in our own climate.

Any sandstone weighing less than 130 pounds per cubic foot, absorbing more than 5 per cent. of its weight of water in twenty four hours, and effervescing more than feebly with acid, is likely to be a second-class stone, as regards durability, where there is frost or much acid in the air.

The following statement by an English authority is of interest, not only because Caen stone has frequently been brought to New York in small quantities, and was once employed in construction of the fronts of the old building of the Nassau bank, corner of Nassau and Beekman streets, and of others, and is still used for interior work, but from its applicability to our native soft limestone-freestones:

Experience proves that Caen stone will not resist the dissolving power of water charged with carbonic acid gas; and as the rain-water of our large towns contains a considerable quantity of that gas, it is not expedient to employ this stone in any situation where water is likely to lodge or even to be taken up by capillary action, unless indeed the projecting parts be protected by metal. In upright walling above the plinths, and in the sheltered portions of cornices, it can be employed when judiciously selected; and in internal work, with safety and economy. The bedding of the stone should be observed.

Mr. G. Godwin, F. R. S., of London, England, states, in regard to this stone, that much of it is really good, but affords only small blocks. That which is brought into England—

cannot be depended on and ought not to be used in external work. With regard to Buckingham palace, where Caen stone was used, that was perhaps the most remarkable failure that ever was witnessed. He recollected seeing the new front of that palace about a year or a year and a half after it was finished (1847), and he found many parts in a state of perfect ruin. Large masses of stone were in the habit of falling from the cornices, to the great danger of the sentinels below, and the result was the necessity of knocking off vast portions of the decorations and making them good with cement, painting them several times, with a frequent necessity for repeating that costly process.

Again, in regard to Westminster abbey, an English writer (*b*) remarks:

Of the exterior I will say nothing. All its old features had perished by the end of the seventeenth century, when they were vilely renewed, and this base restoration is now in its turn decayed.

The abbey had been built about A. D. 1245, its foundations of ragstone from Maidstone, and the rest of the building, of several limestones (Gatton, Caen, etc., and the firestone from Reigate and Godstone). It was afterward repaired with Bath and Portland stones. The greater part of the exterior is now in an advanced stage of decay.

Again there are certain rules of selection, often of local peculiarity, which are yet to be worked out, which refer to the adaptation of a stone to durability in certain positions, exposures, or parts of a building. A few such rules may be suggested as indicated by the study of the forms of decay in this city.

1. No temptation of cheap cost or facility of carving should permit the use—almost universal here—of a soft freestone in the stoops, balustrades, etc., where exposed to sun, street-dust, and wear, unless protected at least by some artificial means.

2. The finest-grained varieties of brownstone, with imperfect lamination, may be introduced with advantage for the projections and those parts most liable to decay, even where coarse material is generally employed in the front.

a Jour. Soc. Arts, London, 1860, Vol. 8, p. 249. *b* Gilbert Scott: *Mediæval Architecture*, Vol. I, p. 176.

3. The life of a brownstone is more apt to be prolonged in a shady but dry exposure, *e. g.*, on the south side of an east and west street, or the west side of a north and south avenue, the shady side of a stoop, etc., if care is taken to prevent the dripping of rain or thawing snow; if not, this position may render it the more liable to decay. Accordingly, a light-colored or more durable stone may be best selected for sun-exposed faces, where possible.

A porous absorbent stone should not be employed at or below the ground line, and the absorption of moisture from below should be prevented by the interposition of some impermeable material, as a damp-proof course. Attention to this rule would have prevented the decay which is shown at the base of most of our brownstone buildings of the earlier construction, usually to a height of one or two feet above the ground line, but sometimes two or three yards, as in the building on the southeast corner of Eighteenth street and Fourth avenue; almost the only decay visible in the excellent sandstone used in Trinity church, New York, is of this nature, extending about a yard above the ground. This experience has borne some fruit in our city, and the insertion of the close-grained compact graywacke or "blue-stone", or sometimes a granite, into the base of most of the recently-erected brownstone fronts, even as a narrow band at the earth line, probably tends to prevent, by its less porosity, the rise of water into the sandstone, and so to delay its disintegration.

SEASONING.—Vitruvius, the Roman architect, two thousand years ago, recommended that stone should be quarried in summer when driest; that it should be seasoned by being allowed to lie two years before being used, so as to allow the natural sap to evaporate, and that it should be tested as to its wasting. Little regard seems now to be paid to this condition, the stone being hurried from the quarry into the building.

It is a notable fact that in the erection of St. Paul's cathedral in London, England, Sir Christopher Wren required that the stone, after quarrying, should be exposed to season for three years on the sea-beach, before its introduction into the building. No such exhibition of carefulness can be witnessed on any sea-beaches in the vicinity of New York city.

POSITION.—It has already been stated that, in order to resist the effects of both pressure and weathering, a stone should be placed on its "natural bed". This usually indicates the plane of original deposition, but not always, contrary to the general statements of the text-books; (*a*) for the lamination may simply be the result of the last period of pressure, *e. g.*, slaty cleavage, in which Sorby and others have shown a rearrangement of the particles, scales, and flakes of the constituent minerals into a stable condition of parallelism. This is illustrated in the constitution of some varieties of our slates, schists, and "blue-stone", and the injury, caused by neglect of this consideration, in the rapid decay and ruin now in progress in the ashlar of our freestone fronts. The stone of one of our oldest buildings, Trinity church, New York, probably owes its excellent preservation in part to the careful attention which was given to the position of the blocks, while in others of comparatively recent erection, though constructed of small blocks of brownstone mostly laid "on bed", the surface of the stone has begun to exfoliate, but not so rapidly and deeply as in occasional blocks standing on edge; for example, many stones below the projecting string-courses in the west front of the church on southeast corner of Thirty-fifth street and Fifth avenue. In many of the most recent buildings the proper mode of construction is seen: *e. g.*, the blocks of gneiss in all churches of that material; the Indiana limestone in the house on corner of Fifty-seventh street and Fifth avenue; the Potsdam sandstone, usually in the new buildings at Columbia college; the brownstone in residences at Fifth avenue and Fifty-first street, and in the lately-erected wings to the Astor library, etc. On the other hand, no attention is paid to the matter in the common stone fronts throughout the city, whether brownstone or Nova Scotia stone. Many prominent buildings of recent erection show the same disregard of the principle, *e. g.*, the marble ashlar of the Union Dime Savings bank, in which a large number of the blocks stand on edge and are in many cases fissured; the Lenox library, in which about 40 per cent. of the ashlar consists, in the alternate receding courses, of blocks of the Lockport limestone set on edge; the Drexel building, on the southeast corner of Wall and Broad streets, in which all the white marble ashlar dressings and even the projecting quoins stand on edge, etc. Indeed, in this city the proper arrangement of building stones in this respect, where apparently observed, has really been rather a matter of the builders' convenience, due to the small size or square form of the stones employed, than of any scrupulous attention to the conditions of durability. Other phases of the principle involved in the position of stone in a building have been already sufficiently discussed.

FORM OF PROJECTIONS.—The following statement by an English authority possesses even greater claim to consideration, in the exigencies of our more severe climate:

> In this climate water will invariably accumulate upon an exposed projection, and from thence, by the natural laws of gravitation, will run downward upon the surface beneath. * * * The continued permeation by water must materially injure the durability of any structure. Upon brick and stone, especially in winter, is this effect noticeable, when the repeated alternate freezing and thawing rapidly affect the quality of materials, and by a disintegration of particles impair the strength of the entire mass. * * * All projections from a building exposed to the weather should be "throated", that is, a narrow groove should be cut, extending the entire length, upon their under side. The water gathering upon the upper part of the window-sill, or whatever the projection may chance to be, flows over the upper edge to the lower and to the under side of the sill, when, instead of following the surface by the attraction of cohesion and finally running down the wall, it is stopped by the groove, and from thence falls to the ground, being unable to further continue its progress upon the surface. The complete efficacy of this device and the ease with which it is adopted are most apparent, and, though it has long been in use, is rarely introduced among the specifications of an architect. (*b*)

a Notes on Build. Construction, Part III, p. 9. *b The Architect*, London, England, 1870.

The severity of our climate even requires the further care that the upper surface of projections should be so cut as to prevent the lodgment or long retention of deposits of either rain water or snow. It is immediately above and below such deposits that the ashlar of our fronts is most rapidly corroded and exfoliated, an effect evidently due mainly to the repeated thawing and solution, freezing and disintegration, which are caused by the water, slush, and snow which rest, often for weeks, upon a window sill, balcony, cornice, etc. Thus from the initial and inexcusable carelessness in the construction and form of the projections, and, later, the neglect of the house-owner, due to ignorance of the results involved, to remove the deposits of snow, etc., as fast as they accumulate on the projections, is derived a large part of the discoloration of the marble, Nova Scotia stone, or light-colored granite, and especially the exfoliation of the brownstone beneath the window-sills, balconies, etc., by the water alternately trickling down the front and freezing, by day and by night, for long periods.

The benefit of this plan is well illustrated on the east, south, and west sides of the city hall of New York city, the heavy projecting marble cornice of the string-course above the first story being deeply undercut, and affording a complete protection from the rain to the line of dentilated decoration immediately beneath it. Accordingly the latter displays no evidences of decay. On the other hand, the general need of this device is testified by a study of the course of the decay which attacks the stone fronts of our buildings. In almost all cases the first part of the ashlar to decay is that immediately beneath the windows. If the projecting stone sill is horizontal, or inclines slightly outward and downward, the rain water falling upon it, and, still more, that derived from the thawing of the snow which lodges in winter upon the sill, flows over the front edge of the sill, over its under surface, and down the surface of the ashlar to the lintel of the window below, in a band as wide as the sill above, or sometimes farthest along a line beneath the middle of the sill, and so produces a triangular or rectangular patch of moisture on the stone, with the apex reaching partly or entirely to the lintel of the window below. If, however, the sill inclines inward toward the house, the water trickles from one or both ends of the sill in a narrow band down the ashlar. After a storm, when the house-front has become rapidly dried, partly from the wind, partly from the free drainage down the lamination planes of the ashlar standing on edge, the stone sill remains water-soaked from the horizontal position of its laminæ, or from the thaw of the snow lodged upon it, and these triangular patches or the lateral streaks are kept moist, it may be, for days afterward. Throughout that portion of the ashlar, therefore, chemical action by day and the work of frost by night continue in progress alternately far longer than elsewhere upon the front. If the material is brick the surface is first discolored, the mortar removed from the joints, and at last the surface of the brick itself is eroded under the patches or streaks of moisture. Examples of this are seen in the brick fronts of the older streets.

If marble, the surface assumes a dirty yellowish color, the joints are widened, and the surface soon becomes roughened. Examples are seen in the marble fronts on the north side of Murray street, between Church street and West Broadway, etc.

If light-colored freestone, a blackish-gray, irregular discoloration begins, which may become very disagreeable to the eye, and a serious decay ensues. Examples are seen in fronts on the corner of Christopher street and Greenwich avenue, etc.

If brownstone, the discoloration hardly precedes the rapid disintegration, the surface peeling off in thin sheets over the triangular patches below the windows, or in long vertical streaks or bands on either side to the depth of 1, 2, or 3 centimeters, even while the general area of the front still retains, in sharp contrast, the smooth surface of its original dressing. Examples of this destruction are seen in its first stages all along the lower part of Fifth and Madison avenues below Forty-second street, and, still farther advanced, in the older streets.

If granite, discoloration has been often produced, but the use of this excellent material is too recent in our modern city to furnish the evidences, sure to follow, of deeper disintegration.

Again, the surface of the ashlar exhibits a similar decay just above the lines of projections, *e. g.*, of long business sign-boards, heavy string-courses, cornices, the lintels of doors and windows, etc., peeling off in the same way as the lowest courses of the front just above the ground line. This, too, seems to be chiefly due to the snow which lodges on these surfaces, and, in thawing, keeps moist the surface above. So, also, balconies bring speedy destruction to the stone surfaces beneath them, especially if their flooring permits the trickling of water down the front, and at the same time shelters it from the sun and wind. Thus, one may see in our streets, for several days after a snowfall, entire blocks of the finest residences with their fronts spotted with snow on all projections, constantly thawing and freezing, with corroding streams of water trickling their way down the front. In most cases these snow deposits on window-sills, lintels, etc., could be as readily swept from their lodgment by means of a broom, as they are always removed from the sidewalk. The neglect—which, if applied by our servants to the destruction of furniture within the same houses, would be denounced as slovenly carelessness—is simply due to ignorance.

It requires, therefore, but little observation of our buildings to recognize that, like the beak of the pelican tearing its own breast, the sills and similar projections are serving to eat away the material of the front lying below. A clear understanding of the nature and progress of the erosion, as above described, is first desirable; and this seems to indicate the advisability of adopting, for prevention, some simple device in regard to the window-sills, such as the choice of impervious material not easily water-soaked (perhaps blue-stone), cut in such form above as

to prevent the easy lodgment of rain-water or snow, and throated with a groove underneath the projection to prevent the continuous trickling of water down the front. No such attention appears to be given to the character of the window-sills of most buildings by our architects, though the desired result has been obtained, where a properly throated string-course or cornice coincides with the sills of a line of windows (*e. g.*, in many churches, in a new building of Columbia college, on Forty-ninth street, and also in some churches recently erected), by dispensing with any projection beneath a window and replacing it by a long slope from a narrow, protected sill into the vertical plane of the front—*e. g.*, in the churches on northeast corner of Sixty-sixth street and Madison avenue, etc.

B. ARTIFICIAL MEANS OF PRESERVATION.

Many methods, mostly empirical, have been suggested for the artificial prevention of the decay of building stone, which may be here briefly considered, particularly those which have been resorted to in New York and the adjacent cities. The descriptions of the processes in detail are given in the text-books, (*a*) and it will be necessary to give in this report only the details of processes locally employed. The preparations recommended for this purpose are of two classes, organic and inorganic, according to the nature of the materials used.

1. ORGANIC PREPARATIONS.—All the preparations of this class, depending on the application of a coating of paint, etc., or on the injection of fatty matters, are in their very nature of a temporary character. They have been properly denounced as only costly palliatives, needing frequent repetition, and, therefore, exerting an influence toward the destruction of delicate carving. G. R. Burnell remarks on this subject: (*b*)

> The objection to oil paints consists in the fact that, in proportion as the oils which serve as their vehicles evaporate the particles of the stone they originally protected become again exposed, and even the absorbent powers of the stone itself contribute to this action. It, therefore, becomes necessary to repeat the painting frequently, and thus, in the end, the delicacy of any moldings or carving must be effaced. The unequal rates of expansion of the stone and of the oil paints in time of frost tend to increase the danger of irregular and unequal exposure above attributed to the evaporation of the oil.

Professor Ansted, F. R. S., observed on the same occasion:

> It was easy to see that if a stone could be coated in such a way that moisture could not get into it, and provided there was no moisture in the stone already, the thing was done. But the difficulty was to manage this, and it arose from the fact that no paint, no substance that contained organic matter, could, by any possibility, be long of any use. It might last for a time, but if it was capable of being acted upon by the atmosphere, and became oxidized, then after a time it failed; the surface peeled off and the moisture got in. The moment the moisture got into the stone the mischief began, and the work of destruction would go on as much as if the stone had never been covered at all. The difficulty was to find some material which would form a permanent coating upon the stone, preventing the entrance of atmospheric moisture, and doing so in such a manner that it was not liable to decay from the atmospheric influences to which the stone was exposed.

Coal-tar.—This has a special use in the protection of foundations of weak materials from moisture, the walls and masonry of tanks from acid vapors, etc. (*c*) New York city is fortunately provided with an abundance of excellent material for foundations in the underlying gneiss of the island.

Paint.—In New York I believe this has very rarely been employed for the protection of stone, and could have no lasting effect. By its use in repeated coats, however, the durability of the fronts of Caen stone of several buildings in the lower parts of the city (*e. g.*, the old building of the Nassau bank, the Tontine building, etc.), has been preserved for many years. At Washington a portion of the base of the stone front of the old Capitol, consisting of Potomac marble, was found to be crumbling from rapid decay, and the Secretary of the Interior reported in 1849 that "if left wholly unprotected from atmospheric influences for one-third of the time that marble structures are known to have stood, the noble structure would become a mound of sand". It was subsequently painted, as well as the marble of other public edifices, the President's house, etc. In London, paint has been employed to protect the Caen stone of Buckingham palace, erected in 1847, etc.; the Portland stone of many private and public buildings; the marble of monuments, *e. g.*, that in front of Saint Paul's, etc. A coat of paint is said to last hardly three years.

Oil.—This always discolors a light-colored stone, but only produces a darker shade on our brownstone. For this it has been applied to several buildings, *e. g.*, the first house on south side of Fifty-fourth street, west of Fifth avenue; a house in Sixtieth street, between Fourth and Madison avenues; Trinity church, Brooklyn, etc.

The following is the method employed in its application: The surface of the stone is first washed thoroughly clean, allowed to dry, then painted with one or several coats of boiled linseed oil, according to the taste of the owner, and finally with a weak solution of hartshorn in warm water to produce uniformity of tint. The oil has been found to sink about a quarter of an inch into the stone. Any new block afterward inserted into a front thus oiled, in undergoing repairs, will need to be oiled in the same way. A front treated by this process may be recognized by its darker color and by the fact that during a rain the water freely runs down the surface, which afterward dries more rapidly than an ordinary front. The experience of several builders and house-owners testifies that such a coating of oil will last four and even five years, very rarely longer, then becomes grayish, partially disappears and requires renewal, and so on repeatedly from period to period. Whenever such a front is taken down, it is found also that the greasy coating interferes with the free dressing of the block of stone.

Paraffine dissolved in coal-tar naphtha (1½ pounds to the gallon) and applied warm. This also discolors a light stone, and, although more lasting than oil, the protecting coats are gradually detached from the stone and

a *Notes on Build. Construction*, Part III, etc. *b* *Jour. Soc. Arts, London*, 1860, Vol. 8, p. 245. *c* *The Manufacturer and Builder*, 1870, I, p. 78.

require renewal as frequently as those of paint. An apparently better method, which has been employed in our western cities, consists in brushing over the surface of the stone or brick-work with melted paraffine, and then deepening its penetration by heating the surface by means of a broad charcoal stove or of a flame. By this the outer pores are thoroughly filled, with little or no discoloration; but the absence of injury to sharp edges, through the direct application of heat, and the permanence of the protection, are yet to be established.

Soap and alum solutions (Sylvester's process), consisting of three-quarters of a pound of mottled or soft soap in a gallon of boiling water, and a half pound of alum in 4 gallons of water. In England "this has been repeatedly tried and answers well in exposed situations, but requires a fresh application about every three or four years".

Beeswax in coal-tar naphtha, or, better, to preserve the color of the stone, white wax in double-distilled camphine.

Rosin in turpentine, oil, wax, tallow, or other fatty substance, used as a boiling solution into which the stone is immersed and impregnated to the depth ordinarily of one inch after two hours. Also a solution of rosin in spirits of wine or naphtha, mixed with a solution of gutta-percha in naphtha. A common receipt consists of rosin, tallow, and oil, consisting of 1½ pounds common rosin, 1 pound Russian tallow, and 1 quart linseed oil; applied hot. By this the stone becomes water-proof, the damp cannot enter, and vegetable substances are prevented from growing upon it.

However, all such wax and oil varnishes are costly, liable to rapid oxidation, and sometimes impair in a high degree the color and the natural characteristics of the stone. In New York city only oil and paint have been used for the purpose, to my knowledge, and are objectionable, not only on account of their transient effect, but because a surface, once so prepared, is rendered ever after incapable of absorbing preparations of the next class (inorganic), from which alone can be expected permanent protection of the durability of a stone.

2. INORGANIC PREPARATIONS.—*Water glass, potassium or sodium silicate* (Kuhlmann's process), applicable only to the preservation of soft limestones and marble, or stones in which calcium carbonate predominates. The surfaces are previously colored to avoid discoloration. The silicate of alkali used should not be the ordinary water glass with an excess of alkali, but one with the greatest possible amount of silica. (*a*) This was applied to the new houses of parliament, London, England, but the stone was so bad, or the water-glass so alkaline, that the result was not as satisfactory as was expected: also to the Louvre and cathedral of Notre Dame in Paris, France, Versailles, Fontainebleau, the city hall in Lyons, the cathedral at Chartres, etc.

St. Charles church in Vienna, Austria, was fast going to destruction, but the decay has been arrested by means of this process. Potassium silicate was used, though more costly, because less likely to effloresce than the sodium salt: the two coats applied were perfectly transparent and left the color and the natural qualities of the stone unchanged. (*b*)

Water glass and chloride of calcium or of barium (Ransome's indurating solutions). The following directions are given for this process: Render the surface of the stone clean and dry: dilute the potassium or sodium silicate in from 1 part to 3 pints of soft water, just thin enough to be absorbed freely by the particular stone. Apply with a whitewash brush, say a dozen times, leaving no excess on the face, till it ceases to penetrate, and is about to remain glistening on the surface; allow it to dry perfectly, a clear day or so; then apply freely the solution of calcium chloride, brushing on lightly without froth. (*c*)

Szerelmey's stone liquid. Water-glass, combined with a temporary wash of some bituminous substance.

Petrifying liquid of Silicate Paint Company. *Barium solution*, followed by ferro-silicic acid, or barium solution, followed by calcium superphosphate; soluble *oxalate of aluminium*, applied to limestones. The last three processes produce no efflorescence upon the stone.

Wash of copper salts, as proposed and used by Dr. Robert, in Paris, to arrest the formation and growth of vegetation on the surface of stone. The results already reported imply a considerable aid in the preservation of building material, and may yet be found serviceable in New York to prevent the growth of *confervæ*, etc., which find a favorite habitat as a green film upon the shaded surfaces of Nova Scotia stone, and, as especially observed in Central park, seem to exert a corrosive action upon them.

In New York, various preservative preparations have been used within the last ten or fifteen years, styled "silica petrifying liquid", "durosco," etc., especially on the brick-work, but partly on the brownstone of many buildings (*e.g.*, the brownstone of the *Evening Post* building, four years ago; the brick factory in Twenty-eighth street, between Sixth and Seventh avenues; the brick-work in the rear of the Florence flats, Eighteenth street and Fourth avenue; the brownstone houses on southwest corner of Thirty-ninth street and Fifth avenue; the brick-work of the gables and top bed of all platforms in the balconies of the Union League club in Fifth avenue, etc.). In most cases these preparations, so far as tried, have resulted in complete failure, not arresting the exfoliation.

To my knowledge, no investigation worthy of the name has yet been undertaken in this city for the protection of its stone-work, though there is every promise that a proper and low priced preservative might be discovered, possibly even in the refuse of some of our chemical factories. If not for the ashlar of the fronts, at least for the

a For mode of preparation see *The Manufacturer and Builder*, 1871, III, 205: "How to prepare soluble glass."

b *Manufacturer and Builder*, 1869, I, 82.

c *The Am. Arch. and Builder*, 1877, II, 21, 38.

hewn stones employed for window-sills, string-courses, cornices, and moldings, it would seem false economy to use any porous stone, without every condition of protection to be found, in the form of its cutting and in the application of a suitable artificial preservative.

It will doubtless be found that only those stones, which possess a porous texture and strong absorptive power for liquids, will be found particularly available for protection by artificial preservatives. In the spongy brown and light olive freestones, a marble full of minute crevices, and a cellular fossiliferous limestone, a petrifying liquid may permeate to some depth, close up the pores by its deposits, and incase the stone in solid armor; while upon a more compact rock, such as a granite or solid limestone, it can only deposit a shelly crust or enamel, which time may soon peel off.

In this connection, therefore, three suggestions may be offered: 1st, that householders invoke the magic use of the broom on the fronts of their residences as carefully as upon the sidewalks; 2d, that house-builders insist upon the undercutting of all projections, and the exclusion of brackets or other supports to sills and cornices, which only lead to the oozing of water and a line of corrosion down the ashlar; 3d, that house-repairers recut the projections in this way, whenever possible, and entirely avoid the use of paint, oil, or other organic preservatives.

If a rough estimate be desired, founded merely on these observations, of the comparative durability of the common varieties of building stone used in New York city and vicinity, there may be found some truth in the following approximate figures for the "life" of each stone, signifying by that term, without regard to discoloration or other objectionable qualities, merely the period after which the incipient decay of the variety becomes sufficiently offensive to the eye to demand repair or renewal:

	Life in years.
Coarse brownstone	5–15
Laminated fine brownstone	20–50
Compact fine brownstone	100–200
Blue-stone	Untried, probably centuries.
Nova Scotia stone	Untried, perhaps 50–200
Ohio sandstone (best siliceous variety)	Perhaps from one to many centuries.
Limestone, coarse fossiliferous	20–40
Limestone, fine oolitic (French)	30–40
Limestone, fine oolitic (American)	Untried here.
Marble (dolomite) coarse	40
Marble (dolomite) fine	60–80
Marble, fine	50–200
Granite	75–200
Gneiss	50 years to many centuries.

Within a very few years past it has become frequent to introduce rude varieties of rusticated work into the masonry of buildings in this city, or to leave the stone rough and undressed in huge blocks, especially in the basement or lowest stories, where it is under close and continuous inspection, and the results of its decay will be disguised by its original rough surface. Although there are certain large buildings in which such a massive treatment of stone may be appropriate, its common use, with stones of known feebleness or lack of durability, is a disingenuous evasion of responsibility and a mere confession of ignorance, want of enterprise, and despair, in regard to the proper selection of building material and in regard to its protection.

Finally, it may be pointed out that many of the best building stones of the country have never yet been brought into this city: *e. g.*, siliceous limestones of the highest promise of durability, allied to that employed in Salisbury cathedral; refractory sandstones, like some of those of Ohio and other western states, particularly fitted for introduction into business buildings in the "dry-goods district", storage houses, etc., where a fire-proof stone is needed; and highly siliceous varieties of Lower Silurian sandstones, such as occur near lake Champlain, quartzitic and hard to work, like the Craigleith stone of Edinburgh, but possessing the valuable qualities of that fine stone in resisting discoloration, notwithstanding its light color, and in remarkable resistance to disintegration.

As it is, we have many and need many varieties of stone for our various objects, but do not know how to use them. It is pitiable to see our new buildings erected in soft and often untried varieties of stone, covered with delicate carvings of foliage and flower-garlands, which are almost certain to be nipped off by the frost before the second generation of the owner shall enter the house. It is now time for one who loves stone to express his indignation at the careless and wasteful way in which a good material is being misused.

In conclusion, it is a point worthy of attention that there is at present a strong tendency among many owners of property, and therefore many builders and architects in New York, to entirely reject or greatly limit the use of stone in construction, both in the commercial district and in that which includes the better class of residences.

In the commercial district granite was for some time a favorite material, and constitutes many of our most important buildings. Later it was largely supplanted by the white marbles brought from numberless quarries in Westchester county, western Massachusetts, and Vermont; but of late another change of taste and judgment has occurred, and it has been observed:

> The architects of the present generation found commercial New York an imitation of marble, either in cast-iron or in an actual veneer of white limestone. They are likely to leave it brick.

This city, and, to a large extent, Brooklyn, have passed the period in which frame buildings were permitted, though they never were as abundant as in the newer cities and towns of the west, on account of the large supply of brick clays along the Hudson river, and the easy importation of bricks from Europe and from points along our own coast. In the reports of the fire underwriters, the stone is disregarded as a mere veneer, and all such buildings are properly classified as brick.

Less than 1 per cent. of our building material consists of stone, so that New York is now practically a city of brick. Examples of the preference now largely given to this material are found in many conspicuous structures which have recently risen in this city and Brooklyn: *e. g.*, the storage buildings at Forty-second street and Lexington avenue; the Produce Exchange building in lower Broadway; that of the Long Island Historical Society in Brooklyn, etc.

The definite character and use of many of the most important avenues and entire districts are yet unsettled; and there are abundant indications of cheap display, in fragile veneer and constructions of a temporary character, which are rendering this a period of shams. There are evidences, however, of the gradual recognition of the practical business advantages, in the way of credit and continuous patronage, which are derived from durable massive buildings, with solid and imposing façades, with which the business and names of firms may yet be associated for centuries. The general acceptation of this idea will form the last period—that of stability—in the history of our great metropolis, and then there will be a proper and intelligent use and increased demand for the several varieties of stone.

The present preference for brick is mainly due to the failure of granites and marbles to resist fire in the furious conflagrations in the tinder-boxes at Chicago and Boston—although brick walls as well become warped and useless in the re-erection of the buildings—and to a conclusion which appears to me hasty and uncalled for, from the unfavorable results of the experimental and unnatural trials, in fiery furnaces, of series of our building stones, by several investigators. Such a conclusion seems to be unwise and unfair, so long as our present habit of internal construction is aptly represented by the following description:

> Our buildings are, in truth, ingenious combinations of flues, greater or smaller, mostly of combustible substance, and commonly of thin material, set side by side across our floors and up our walls, opening out here and there into hollow spaces walled with wood, and out of our reach. Every fire that occurs gives us new warning that our way of building is unsafe. All our common methods have been developed in the effort to attain one class of qualities—lightness, quickness, and ease of construction, and economy, or rather cheapness. As usually happens to people whose aims are one-sided, we have got into trouble. Our buildings do not last; often they will not bear the use we put them to; they burn like straw. Other people have found out how to build better than we, but we like our own way, and we will learn nothing from them. We box our floors with thin plank set edgewise, our partitions with smaller pieces of the same stuff; we fur our walls with strips of the same. Then we case all in with thinner boards and friable plaster on still thinner lath. The building is a series of communicating flues partially protected outside, but wholly exposed within, through which fire and vermin may play at will, and through which we cannot trace them till they have done their mischief. All this is convenient and cheap, for it is quickly put up and takes little material. If we use iron, as we must, we make it hollow also for strength's sake. This would do no harm if the hollows were no larger than they need be, and were properly closed in; but we build great boxes to simulate masses of stone, and we expose them to the fires of blazing wood which we know will destroy them. At the persuasion of underwriters we put up cornices of galvanized iron, which will not themselves burn, but which are thin shells turned upon wood, and will at once convey the fire behind them. (*a*)

Add to all this our hatchways and elevator-shafts, by which a fire, starting in the basement, is conveyed at once to the attic, the beams of the wooden flooring often resting upon girders in the center of the building, as it were, a very house of cards—these girders, too, supported merely on slender stone piers in the basement, and on light iron pillars in the upper stories, and every floor filled with a mass of combustibles, especially in the "dry-goods district"; and we find an accumulation of materials in false and improper conditions, whose combustion will overcome the most refractory walls, and which should never be permitted to endanger human life and property in a so-called metropolitan city. On inquiry, I find among insurance men a unanimous conviction, decidedly and strongly expressed, that there is not in the city of New York a single absolutely fire-proof building—not one whose walls may not crumble before a storm of fire from without, or in which either flooring or partitions, or both, will not probably yield to the internal conflagration of their ordinary contents. A few edifices may approach the conditions required, but even in one of these a recent fire on the seventh floor, fed merely by office furniture, shriveled up the flimsy so-called "fire proof" partitions and gutted the entire floor. The very material, perforated brick, which was used in these partitions, is still being hurried into new "fire proof" buildings, now in process of construction in Fiftieth street and elsewhere. Nevertheless, it is generally admitted that much progress and great improvement have been made, during the last few years, both in the choice and arrangement of building materials for the protection of our buildings from fire; with an enlightened public opinion, much more may be expected. We have, fortunately, at our very doors, vast tracts of fire-proof materials—the belt of brick clays along the Hudson river, and the still more extensive band of clays stretching across New Jersey, excellently adapted for all varieties of bricks, terra-cotta, and tiles, to say nothing of the resources of our commerce in the importation of similar materials from the whole Atlantic coast—which we ought to and must use for interior construction as a matter of the wisest economy, and, in association with which, our building stones, in all their variety and enormous supply, will find their proper place. When, at least in the business districts of the city, the interiors of the buildings are generally supplied with a minimum of wood, subdivided with tile, slate, or concrete flooring and doors, and sufficient partitions of brick or terra-cotta,

a The Arch. and Build. News, 1879, V. 89.

and roofed with tile, slate, or concrete upon fire-proof backing or supports, the nature of the stone used for the exterior will matter little, so far as concerns protection from fire, since it will not be exposed then, as now, to the unnatural and unnecessary furnace-test of furious flames from neighboring buildings.

The other objection to the use of stone, and one which has been specially prompted by the decay of the brownstone ashlar employed extensively in our buildings for private residence, is founded upon its lack of durability and speedy dilapidation or discoloration. The hasty statements of despairing architects, in denunciation of the brownstone, are sufficiently answered by reference to the texture of the still softer oolite, which mediæval architects were content to employ, and whose fragility seems to have been at last counteracted by modern devices. When proper investigations shall have been made, it is probable that the very porosity of the stone, which now renders it particularly sensitive to atmospheric attack, may best avail for the absorption of some cheap and durable mineral preservative, and that the present use of such stone in its raw, crude, and unseasoned state will be hereafter considered merely an evidence of the unintelligent and wasteful way in which we now work up our materials. Surely, since our city is placed in a region occupied on every side by inexhaustible supplies of sedimentary and crystalline rocks, remarkably well fitted for building construction, their surfaces scraped nearly bare by ice-action during the great glacial period, and thus most favorably exposed for economical exploitation, and the whole region is crossed by a radial network of routes of transportation by water and rail, at the least cost, centering in this city, the natural materials for building thus offered to us should not be hastily neglected or rejected, before their nature has been thoroughly understood.

APPENDIX.

APPENDIX

EXPORTATION OF STONE.

Slate is now being quite largely exported to Australia and New Zealand; some to England and Germany, and some to South America and the West Indies. The most extensive exportations are perhaps to Australia. School slates are quite largely sent to Germany. Marble is exported to the British North American provinces, to the West Indies, and to Cuba; and the reports of the Philadelphia custom-house show that in 1878 marble was exported to England; in 1879 to Belgium, England, and Ireland; in 1880 to Belgium, England, and Japan. Soap-stone has been exported to England. Quite a large amount of Carrara marble is brought to the port of Boston and from there distributed to the British North American provinces. The reason why this is done under the double duty instead of being shipped direct to the market where it is consumed, is because large amounts of marble are shipped constantly to this country while these other markets receive but a small amount at a time; also because ships will bring cargoes for less money to Boston than to Halifax on account of being more certain of procuring a return cargo. These conditions account, in part at least, for the stone of foreign production that is shipped from the different ports of the United States.

IMPORTATION OF STONE INTO THE UNITED STATES.

The custom-house reports show the importation of stone into the United States from nearly every country in the world. It is well known, of course, what stone comes from Scotland, England, Ireland, France, Germany, Belgium, the British North American provinces, and from Italy, and it is also known that onyx has been imported from Mexico, marble from Spain and Portugal, etc., and that marble has been imported from Sicily, granite from Norway and Sweden and Russia, and marble from Africa, but it is not so easy to account for the stone that is imported from British West Indies, Honduras, Central America, Cuba, Hayti, South America, Holland, and Turkey.

The only countries from which stone is constantly in the market in this country are Italy and Nova Scotia. The granite and sandstones from Scotland are imported for special orders. The same may be said of the granite imported from England and Ireland and the colored marbles from France and Germany—the brown sandstone of Germany, and the Caen stone of France.

The statistics of the Philadelphia custom-house show a large amount of dressed marble imported from England. Some stone is brought as ballast from Brazil, and marble and manufactures of marble from the Danish West Indies and the Netherlands, Brazil, Belgium, Cuba, British West Indies, Sweden and Norway, and some manufactures of slate from Germany. It is also stated that marble has been imported from Nova Scotia and from Canada. Some stone is entered on the custom-house books as "imported manufactured product", which consists of various carved figures picked up by tourists in different parts of the world. This fact may account for stone imported from any country; for instance, if a figure is carved in China and finds its way to Turkey, and is shipped from there to the United States, it will appear as the manufactured product of stone from Turkey. What the manufactures of stone are that have been shipped from South America and the West Indies could not be determined. Marble comes mostly in the unmanufactured state. The cost of labor is so much less in Italy than in this country that the Italian marble, after paying the cost of transportation and a duty of 50 cents per foot and 20 per cent. ad valorem, can be sold in New York about as cheap as the Rutland marble. The cost of transportation from Carrara, however, does not differ much from the cost of transportation of a like amount from Rutland, Vermont.

IMPORTS AND EXPORTS OF MARBLE AND STONE, BY COUNTRIES, FOR THE YEAR ENDING JUNE 30, 1881.

IMPORTS

Countries from which imported.	Marble and stone, and manufactures of, not elsewhere specified.	Countries from which imported.	Marble and stone, and manufactures of, not elsewhere specified.
Total	$367,7[illegible]	Quebec, Ontario, Manitoba, and the Northwest territory	$17,420
Belgium	11,[illegible]	British West Indies	89
China	97	Hong Kong	897
France	26,812	Italy	554,210
French West Indies	9	Japan	84
French possessions in Africa and adjacent islands	8	Mexico	1,602
Germany	42,[illegible]	Netherlands	4,487
England	7[illegible]	Spain	55
Scotland	77,1[illegible]	Cuba	5
Ireland	18	Sweden and Norway	74
Gibraltar	4	Turkey in Asia	2
Nova Scotia, New Brunswick, and Prince Edward island	712,[illegible]	United States of Colombia	25

EXPORTS

Countries to which exported.	MARBLE AND STONE.		Countries to which exported.	MARBLE AND STONE.	
	Rough or unmanufactured	Manufactured		Rough or unmanufactured	Manufactures of.
Total	$220,562	$[illegible],4[illegible]	Hong Kong		$150
			British possessions in Africa and adjacent islands		12,003
Argentine Republic		4,131	British possessions in Australia	$9,100	77,530
Belgium	176	[illegible],467	Hawaiian islands		4,363
Brazil	2,500	[illegible],[illegible]87	Hayti	331	3,846
Central American states		1,500	India		350
Chili		2,688	Japan		338
China		45	Liberia		679
Denmark		7,650	Mexico	25	10,948
Danish West Indies	42	120	Netherlands		8,225
France	35	[illegible],145	French West Indies		450
French West Indies	84	7	Dutch Guiana		715
Miquelon, Langley, and St. Pierre islands		129	Dutch East Indies		130
French possessions, all other		136	Portugal		234
Germany	3,220	23,207	Azores, Madeira, and Cape Verde islands		198
England	4,581	113,320	Russia, Asiatic		148
Scotland	280	5,563	San Domingo		359
Ireland		7,849	Spain		38
Nova Scotia, New Brunswick, and Prince Edward island	5,517	5,963	Cuba	15	14,339
Quebec, Ontario, Manitoba, and the Northwest territory	194,061	59,942	Porto Rico		2,969
British Columbia		1,667	Spanish possessions, all other		163
Newfoundland and Labrador	363	253	Sweden and Norway		718
British West Indies		13,390	United States of Colombia	32	5,418
British Guiana		1,577	Uruguay		910
British Honduras		488	Venezuela		3,946
			All other countries and ports in South America not elsewhere specified		262

EGYPTIAN BRECCIA.

The very celebrated universal breccia of Egypt is composed of rounded pebbles of most diverse forms, color, and material. It occurs about 12 leagues to the east of Keneh, in the Arabian chain of mountains, not far from the valley of Kossier, and on the railroad going from the Nile to the Red sea. The Egyptians have extracted from it some immense blocks—such as the antique sarcophagus of Alexander, which was 15 millimeters in circumference, and which was covered with hieroglyphics and delicate sculptures. The Romans carried away from Egypt a great number of such monuments at the time of the Pharaohs, and they themselves quarried this breccia. One can regard the universal breccia of Egypt as one of the hardest stones, one of the richest in color, and one of the most beautiful. Almost all the museums in the world contain statuary or ornamental constructions of some kind cut from this rock. The variety which appears to have been most admired by the ancients had a green color. The essential components of this variety were fragments of argillitic schist and porphyry, with here and there a pebble of granite, which, being much harder than the others, rendered the rock very difficult to work. This rock

is not at all uncommon or confined to Egypt; a Grecian rock has been brought into the market which very closely resembles it. From Hainaut, in Belgium, a rock has been obtained which is nearly the same as that found in the Devonian formation in the southern Vosges; and at still other places this rock has been obtained.

We can increase the list by calling attention to some of the American varieties (Boston conglomerate). (Delesse, p. 24.)

CHLORITE ROCK.

Rocks composed of chlorite are found in various parts of the world, and are used for ornamental constructions, especially for making smaller objects which can be turned with a lathe. These are the stones which are called by the French *pierres ollaires*. No rocks of this nature have thus far been brought to our attention in the United States. A chlorite from Potton, in Lower Canada, has been used. It is found in beds of Lower Silurian age lying immediately upon the Laurentian rocks; it is associated with dolomite or serpentine, and, like the latter rock, it contains some chromate of iron. (Delesse, p. 27.)

ALGERIAN ALABASTER.

In his geological explorations of the province of Oran, M. Ville found at Aïn Tembalek, near the Ysser, five deposits of a very curious alabaster. M. Delmonte, who was a marble-worker at Carrara at one time, who had admired this marble in ancient monuments, the origin of which was unknown to him, explored it and introduced it into market, and it is now called the Algerian alabaster. It is a fibrous calcite, veined and translucent, and has especial properties. It has a horizontal stratification, while the ordinary alabaster is concentrically banded—a circumstance arising from its concretionary formation in cavities, or often stalactites. Heated, it becomes brown, owing to its contents of iron carbonate; some specimens are red, some golden, yellowish, or brown, some pure white, and some a mixture of all these colors; specific gravity, 2.728. It is so compact that it is more difficult to cut than ordinary marble. It stands the weather very well, as a column found in an ancient quarry demonstrates. It forms extensive beds, which are regularly and horizontally formed, having a post-Tertiary origin, since it rests on Tertiary deposits, and lies between layers of a sweet-water formation, or travertine, which is abundant in little basins in the province of Oran; and the Algerian alabaster is simply a modification of this travertine.

The Romans, who brought the materials for decoration from all parts of the world, have explored the Algerian alabaster upon a grand scale. The Turks also explored the same quarries, and adorned their mosques with materials from them. It has been used in mosaics, and even for statuary.

ITALIAN MARBLE (CARRARA).

According to Consul Robert W. Welsh, (*a*) from 125,000 to 150,000 tons of marble are sent out from Carrara to various parts of the world every year, but it is all sold for cash. The sale of the marble, the delivery of it at the railway station or at Leghorn or Genoa, and the receipt of the cash equivalent, make up the entire commercial business of the place.

Carrara marble is a luxury, and the demand for it depends upon the condition of "the times" in the various countries to which it is exported. The condition of the world has been such that the only country with which dealers in Carrara marble had a good trade in 1879 was the United States.

STATEMENT OF THE EXPORTATION OF MARBLE FROM THE CONSULAR DISTRICT OF CARRARA IN THE YEAR 1879.

	Tons.
Block marble	76,370
Sawed marble	20,526
Worked marble	37,538
Total	134,434

STATEMENT OF THE EXPORTATION OF ALL KINDS FROM 1872 TO 1879, INCLUSIVE (CARRARA).

	Tons.
1872	116,061
1873	117,115
1874	117,282
1875	121,774
1876	103,511
1877	118,268
1878	105,019
1879	134,434
Total	933,464

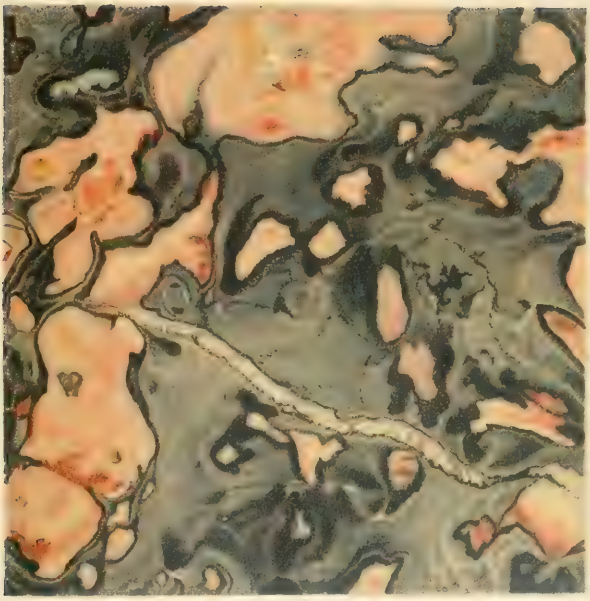
The above statements are taken from the *Corriere Carrarese*.

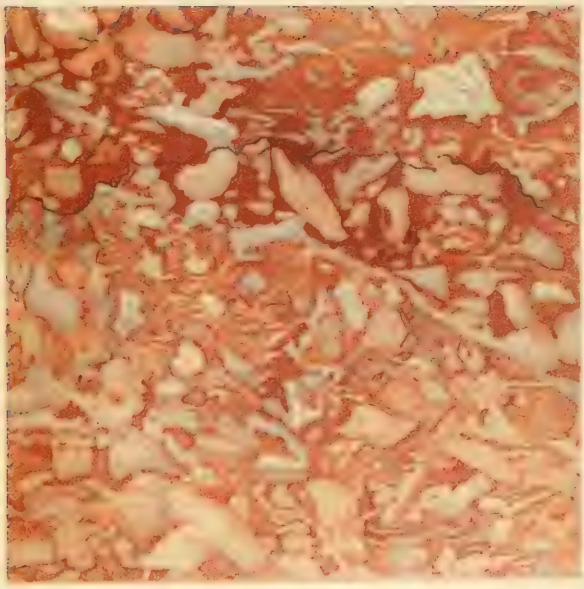
a Report to State Department, October 31, 1880.

BIOTITE GRANITE WITH EPIDOTE

LEBANON, OREGON

MARBLE.

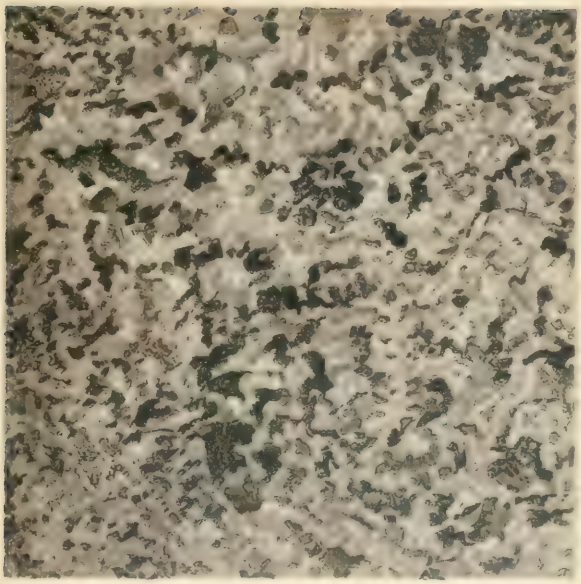




HORNBLENDE GRANITE

HORNBLENDE BIOTITE GNEISS

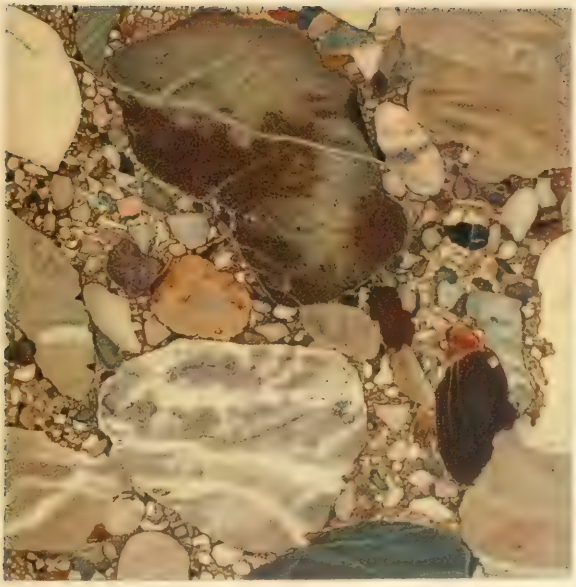
MIDDLETOWN, CONN.



MARBLE

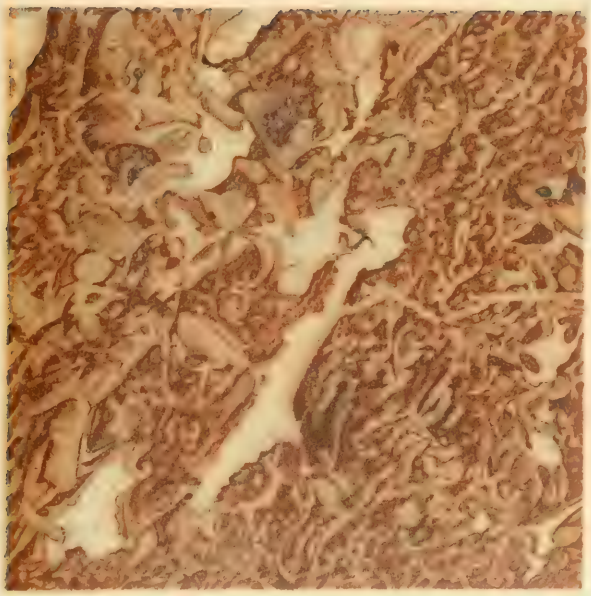
POLK, HENRY [illegible] COUNTY

TRIASSIC SANDSTONE.

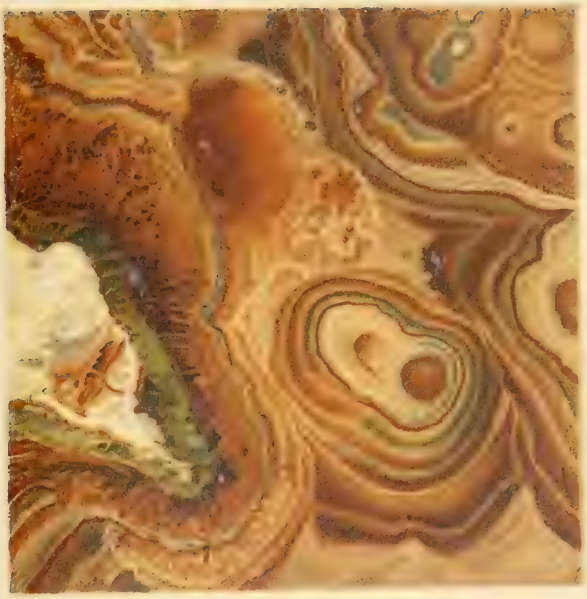


LIME STONE BRECCIA

SERPENTES



MARBLE



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